Project MedTech

- PART II: Appendices

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APPENDIX A

PROJECT RISK ANALYSIS

MedTech – MF2003
2008-05-13

PROJECT RISK ANALYSIS

Probability and impact are valued on a scale 1-4, explained below.

A total ≥ 8 are given a plan so that the project members can prevent the risk from happening.

Probability

1 – Minimal risk

2 – Less probable

3 – Probably

4 – Highly probable

Impact

1 – Neglectable

2 – Noticeable

3 – Serious

4 – Catastrophic

Risk	Probability	Impact	Total	Prevention
Unique components (long delivery time)	3	3	9	Examine the suppliers. Use standard products as far as possible.
Illness among the group members (high absence)	2	2	4	
Loss of group member (1)	1	1	1	
Absence at final phase (presentation, report etc)	2	2	4	
Loss of data (report, code etc)	1	4	4	
Long production time (wait time for workshop)	3	2	6	
Loss of components (overheating components, motors etc)	4	3	12	Caution. If components are cheap, order some extra.

Construction faults (play in components etc)	2	4	8	Critical examination of the design prior to construction. Keep design simple, use prototypes and tests. Consult competent people.
Design faults	2	3	6	
Constrained by choice of software	1	3	3	
Personal injuries (during project work)	1	2	2	
Lack of information (hard to reach key competence and resources)	3	2	6	
Financial resources run out	1	3	3	
Violation of Medical regulations	1	4	4	
Can't meet requirements for quality certification (CE)	4	1	4	
Conditions change during project (defined by assigner, authorities)	1	3	3	
Corporate partners back out	1	3	3	
Sponsor or supervisor back out	1	2	2	
Problems with development environment				
Premises	1	2	2	
Software and computers	3	3	9	Use resources available from many computers. Only licensed software.
Lack of motivation (nice spring)	2	2	4	
Problem with group dynamics	2	3	6	
Bad organization (use of resources)	2	3	6	
AWAL	1	3	3	

Miss project deadline	1	3	3
Miss phase deadlines	3	2	6
Strong recession (hard to find components and investors)	1	3	3
Components disappears from the lab	2	3	6
Lack of competence within the group	3	2	6
Too low goals	1	1	1
Too high goals	3	2	6
Overdesigned product (unnecessary functions, adding to much)	3	2	6
Increase of material and component prices	1	2	2

APPENDIX B

PROJECT SUMMARIZING OF LVSF2003:11

MedTech – MF2003
2008-05-13

PROJECT SUMMARIZING OF LVSF2003:11

SAMMANFATTNING AV FÖRESKRIFTER FRÅN LVSF2003:11

Nedan följer ett utdrag av de mest intressanta föreskrifterna från LVSF2003:11 för producerandet av SpastiFlex. De består av allmänna krav, krav på konstruktion och tillämpning, klassificeringsbestämmelser samt lag angående användandet av vissa måttenheter, eftersom den refereras i 10.3.

I. ALLMÄNNA KRAV

1. Produkterna skall konstrueras och tillverkas på ett sådant sätt att de inte äventyrar patienternas kliniska tillstånd eller säkerhet, användarnas eller i förekommande fall andra personers hälsa och säkerhet, när de används under avsedda förhållanden och för sitt avsedda ändamål. Riskerna med att använda produkterna skall vara acceptabla med tanke på fördelarna för patienten och förenliga med en hög hälso- och säkerhetsnivå.

2. De lösningar som tillverkaren väljer för konstruktionen och tillverkningen av produkten skall överensstämma med säkerhetsprinciper och ta hänsyn till det allmänt erkända tekniska utvecklingsstadiet. För att komma fram till de lämpligaste lösningarna skall tillverkaren tillämpa nedanstående principer i följande ordning:

1. Riskerna skall elimineras eller minskas så mycket som möjligt (inbyggd säkerhet skall integreras i konstruktion och tillverkning).
2. I de fall riskerna inte kan elimineras, skall tillräckliga skyddsåtgärder vidtas, t.ex. larm om sådana behövs.
3. Användarna skall upplysas om kvarvarande risker som beror på att de vidtagna säkerhetsåtgärderna inte är tillräckliga.

3. Produkterna skall, i enlighet med tillverkarens specifikation, uppnå de prestanda som tillverkaren har angivit och vara konstruerade, tillverkade och förpackade på ett sådant sätt att de är lämpliga för en eller flera av de funktioner som avses i 2 § lagen (1993:584) om medicintekniska produkter.

4. De egenskaper och prestanda som anges i punkterna 1, 2 och 3 skall inte kunna påverkas i en sådan utsträckning att patienternas kliniska tillstånd och säkerhet, eller i förekommande fall andra personers hälsa och säkerhet, äventyras under den av tillverkaren avsedda livslängden för produkten. Detta gäller när produkten utsätts för sådana påfrestningar som kan uppstå under normala

användningsförhållanden.

5. Produkterna skall konstrueras, tillverkas och förpackas på ett sådant sätt att deras egenskaper och prestanda vid avsedd användning inte påverkas negativt under de lagrings- och transportförhållanden som tillverkaren har föreskrivit.

6. Oönskade bieffekter får endast utgöra acceptabla risker när de vägs mot avsedda prestanda.

II. KRAV PÅ KONSTRUKTION OCH TILLVERKNING

KEMISKA, FYSIKALISKA OCH BIOLOGISKA EGENSKAPER

7.1 Produkterna skall konstrueras och tillverkas på ett sådant sätt att de egenskaper och prestanda som anges under rubriken I. Allmänna krav säkerställs. Särskild uppmärksamhet skall ges åt

- valet av material, särskilt vad gäller toxiciteten och i förekommande fallbrandfarligheten,
- de använda materialens kompatibilitet med biologiska vävnader, celler och kroppsvätskor beroende på det avsedda ändamålet med produkten.

7.2 Produkterna skall med hänsyn till det avsedda ändamålet konstrueras, tillverkas och förpackas på ett sådant sätt att de risker som föroreningar och restsubstanser utgör minimeras för patienterna och för de personer som transporterar, lagrar och använder produkten. Särskild hänsyn skall tas till utsatta vävnader och till hur länge och ofta de är utsatta.

7.3 Produkterna skall konstrueras och tillverkas på ett sådant sätt att de utan risk kan användas med de material, ämnen och gaser som de kommer i kontakt med när de används på avsett sätt eller under rutinförfaranden. Om produkterna är avsedda att administrera läkemedel, skall de konstrueras och tillverkas så att de är kompatibla med de aktuella läkemedlen, i enlighet med de bestämmelser och begränsningar som reglerar dessa produkter, och så att deras prestanda bibehålls i enlighet med deras avsedda ändamål.

7.4 När en produkt som en integrerad del innehåller ett ämne som härrör från blod från människa skall det anmälda organet begära ett vetenskapligt utlåtande av Europeiska läkemedelsmyndigheten (EMEA) om ämnets kvalitet och säkerhet med beaktande av relevanta gemenskapsbestämmelser och särskilt i analogi med bestämmelserna i direktiven 75/318/EEG och 89/381/EEG. Detta ämnes användbarhet som en integrerad del av den medicintekniska produkten skall kontrolleras med hänsyn till produktens avsedda ändamål. I enlighet med artikel 4.3 i direktiv 89/381/EEG skall ett prov från varje sats av bulkvaran och/eller den färdiga produkten av ämnet som härrör från blod från människa kontrolleras av ett statligt laboratorium eller av ett laboratorium som har utsetts av en medlemsstat för detta ändamål.

7.5 Produkterna skall konstrueras och tillverkas på ett sådant sätt att riskerna med ämnen som läcker ur produkterna blir så små som möjligt.

7.6 Produkterna skall konstrueras och tillverkas på ett sådant sätt att riskerna med ämnen som oavsiktligt tränger in i dem blir så små som möjligt med tanke på den miljö som de är avsedda att användas i.

KRAV PÅ TILLVERKNING OCH MILJÖ

9.1 Om produkten är avsedd att användas tillsammans med andra produkter eller utrustningar, skall hela kombinationen, inklusive det sammanlänkande systemet, vara säker och inte försämra produkternas angivna prestanda. Begränsningar i användningen skall framgå av märkningen eller bruksanvisningen.

9.2 Produkterna skall vara konstruerade och tillverkade på ett sådant sätt att följande risker elimineras eller blir så små som möjligt:

1 Risken för skada i samband med produkternas fysiska egenskaper inklusive volym/tryckförhållande, mått och i förekommande fall ergonomiska egenskaper.
2 Risker i samband med miljöförhållanden som rimligen kan förutses som magnetfält, yttre elektrisk påverkan, elektrostatisk urladdning, tryck, temperatur eller variationer i tryck och acceleration.
3 Risker för ömsesidig interferens med andra produkter som normalt används vid undersökningarna eller vid den aktuella behandlingen.
4 Risker som kan uppstå då det är omöjligt att underhålla och kalibrera produkterna (som vid implantat), vid åldrande av det använda materialet eller minskad noggrannhet hos någon mät- eller kontrollmekanism.

9.3 Produkterna skall konstrueras och tillverkas på ett sådant sätt att riskerna för brand eller explosion blir så små som möjligt vid normal användning och vid ett första fel. Särskild uppmärksamhet skall riktas mot produkter i vars avsedda användning ingår att utsättas för lättantändliga ämnen eller för ämnen som kan orsaka brand.

10. PRODUKTER MED MÄTFUNKTION

10.1 Produkter som har en mätfunktion skall vara konstruerade och tillverkade på ett sådant sätt att mätresultaten blir tillräckligt noggranna och tillförlitliga och inom toleranser som är rimliga med tanke på produktens avsedda ändamål. Toleranser avseende noggrannhet anges av tillverkaren.

10.2 Mät-, övervaknings- och presentationsskalorna skall vara konstruerade enligt ergonomiska principer och med hänsyn tagen till produktens avsedda ändamål.

10.3 De mätningar som görs med produkter som har en mätfunktion skall uttryckas i författningsenliga enheter i enlighet med bestämmelserna i lagen (1992:1514) om måttenheter, mätningar och mätdon.

12. KRAV PÅ MEDICINTEKNISKA PRODUKTER SOM ÄR KOPPLADE TILL ELLER ÄR UTRUSTADE MED EN ENERGIKÄLLA

12.1 Produkter som innefattar elektroniska programmerbara system skall konstrueras så att systemens repeterbarhet, tillförlitlighet och prestanda i förhållande till det avsedda ändamålet säkerställs. Vid ett första fel (i systemet) skall detta förhindra eller minimera ytterligare risker.

12.2 Om patientens säkerhet är beroende av en intern energikälla i produkten, skall produkten vara utrustad med möjlighet att kontrollera den interna energikällans tillstånd.

12.3 Om patientens säkerhet är beroende av en extern energikälla, skall produkten vara utrustad med larmsystem som signalerar strömavbrott.

12.4 Produkter som är avsedda att övervaka en eller flera kliniska parametrar hos en patient skall vara utrustade med lämpliga larmsystem som gör användaren uppmärksam på situationer som kan leda till patientens död eller en allvarlig försämring av patientens hälsotillstånd.

12.5 Produkter skall konstrueras och tillverkas så att risken för störningar orsakade av deras elektromagnetiska fält på andra produkter eller utrustningar under användning i den normala omgivningen blir så liten som möjligt.

12.6 Skydd mot risker av elektrisk natur

Produkterna skall konstrueras och tillverkas på ett sådant sätt att risken för oavsiktliga elektriska chocker vid normal användning och vid ett första fel blir så liten som möjligt, under förutsättning att produkterna har installerats på rätt sätt.

12.7 Skydd mot risker av mekanisk och termisk natur

12.7.1 Produkterna skall konstrueras och tillverkas på ett sådant sätt att patienterna och användarna skyddas mot risker av mekanisk natur såsom hållfasthet, stabilitet och rörliga delar.

12.7.2 Produkterna skall konstrueras och tillverkas på ett sådant sätt att de risker som uppstår i samband med produkternas vibrationer blir så små som möjligt, såvida inte vibrationerna är en del av den angivna funktionen. Hänsyn skall tas till den tekniska utvecklingen och de till buds stående möjligheterna att dämpa vibrationer.

12.7.3 Produkterna skall konstrueras och tillverkas på ett sådant sätt att de risker som uppstår i samband med buller blir så små som möjligt, såvida inte bullret är en del av den angivna funktionen. Hänsyn skall tas till den tekniska utvecklingen och de till buds stående möjligheterna att dämpa buller.

12.7.4 Terminaler och anslutningsdon till elektrisk, gasformig eller hydraulisk och pneumatisk energitillförsel, som användaren skall hantera, skall vara konstruerade och tillverkade på ett sådant att tänkbara risker minimeras.

12.7.5 Åtkomliga delar av produkterna (utom delar eller områden som är avsedda för att avge värme eller nå avsedda temperaturer) och omgivningen får inte uppnå potentiellt skadliga temperaturer vid normal användning.

12.8 Skydd för patienter mot risker vid tillförsel av energi eller ämnen

12.8.1 De produkter som är avsedda att tillföra patienten energi eller ämnen skall vara konstruerade och tillverkade på ett sådant sätt att flödet kan fastställas och bibehållas tillräckligt noggrant för att patientens och användarens säkerhet skall kunna garanteras.

12.8.2 Produkterna skall ha en funktion som kan förhindra och/eller visa ett otillräckligt flöde, vilket kan utgöra en fara. Produkterna skall ha en funktion som i största möjliga utsträckning förhindrar att farliga mängder oavsiktligt avges från en ämnes- eller energikälla.

12.9 Kontrollernas och indikatorernas funktioner skall tydligt anges på produkterna. Om det finns en bruksanvisning på produkten eller om bruks- eller anpassningsvariabler markeras på produkten med ett visuellt system, skall anvisningarna vara förståeliga för användaren och i förekommande fall för patienten.

III. KLASSIFICERING

1. ICKE INVASIVA PRODUKTER

1.1 Regel 1

Alla icke invasiva produkter tillhör klass I om inte någon av de regler som anges nedan är tillämplig.

1.2 Regel 2

Alla icke invasiva produkter som är avsedda att leda eller lagra blod, kroppsvätskor eller vävnader, vätskor eller gaser inför en infusion, dosering eller införsel i kroppen tillhör klass IIa i följande fall:

Om de får kopplas till en aktiv medicinteknisk produkt i klass IIa eller i en högre klass.

Om de är avsedda att användas för att lagra eller leda blod eller andra kroppsvätskor eller för att lagra organ, delar av organ eller kroppsvävnader.

I alla andra fall tillhör de klass I.

1.3 Regel 3

Alla icke invasiva produkter som är avsedda att ändra den biologiska eller kemiska sammansättningen av blod, andra kroppsvätskor eller andra vätskor som är avsedda för infusion i kroppen tillhör klass IIb. Om emellertid behandlingen består av filtrering, centrifugering eller utbyte av gaser eller värme tillhör produkterna klass IIa.

1.4 Regel 4

Alla icke invasiva produkter som kommer i kontakt med skadad hud

5 tillhör klass I om de är avsedda att användas som en mekanisk barriär, som tryck eller för absorption av exsudat,

6 tillhör klass IIb om de huvudsakligen är avsedda att användas för sår som har penetrerat huden och bara kan läka efter ytterligare åtgärder,

7 tillhör klass IIa i alla andra fall, även produkter som huvudsakligen är avsedda att reglera sårets bakterieflora.

2. INVASIVA PRODUKTER

2.1 Regel 5

Alla invasiva produkter att användas i kroppsöppningar, utom kirurgiska invasiva produkter och sådana som inte är avsedda att kopplas till en aktiv medicinteknisk produkt,

1. tillhör klass I om de är avsedda för tillfällig användning,
2. tillhör klass IIa om de är avsedda för kortvarig användning, utom om de används i munhålan så långt som till svalget, i en hörselgång fram till trumhinnan eller i en näshåla – de tillhör då klass I,
3. tillhör klass IIb om de är avsedda för långvarig användning, utom om de används i munhålan så långt som till svalget, i en hörselgång fram till trumhinnan eller i en näshåla och inte sugs upp av slemhinnan – de tillhör då klass IIa. Alla invasiva produkter att användas i kroppsöppningar, utom kirurgiska invasiva produkter, som är avsedda att kopplas till en aktiv medicinteknisk produkt i klass IIa eller i en högre klass, tillhör klass IIa.

2.2 Regel 6

Alla kirurgiska invasiva produkter som är avsedda för tillfällig användning tillhör klass IIa om de inte

1. särskilt är avsedda för att diagnosticera, övervaka eller korrigera ett hjärtfeleller fel i centrala cirkulationssystemet genom direkt kontakt med dessa kroppsdelar – de tillhör då klass III,
2. är kirurgiska flergångsinstrument – de tillhör då klass I,
3. är avsedda att avge energi i form av joniserande strålning – de tillhör då klass IIb,
4. är avsedda att ha en biologisk verkan eller att helt och hållet eller till största delen absorberas – de tillhör då klass IIb,
5. är avsedda att administrera läkemedel genom ett doseringssystem, om detta görs på ett potentiellt farligt sätt med tanke på tillämpningssättet – de tillhör då klass IIb.

2.3 Regel 7

Alla kirurgiska invasiva produkter som är avsedda för kortvarig användning tillhör klass IIa om de inte är

6. antingen särskilt avsedda att diagnosticera, övervaka eller korrigera ett hjärtfel eller ett fel i centrala cirkulationssystemet genom direkt kontakt med dessa delar av kroppen – de tillhör då klass III eller
7. särskilt avsedda att användas i direkt kontakt med centrala nervsystemet – de tillhör då klass III eller

8. avsedda att avge energi i form av joniserande strålning – de tillhör då klass IIb eller
9. avsedda att ha en biologisk verkan eller att helt och hållet eller till största delen absorberas – de tillhör då klass III eller
10. avsedda att genomgå en kemisk förändring i kroppen, utom om produkterna sätts in i tänderna, eller för att administrera läkemedel – de tillhör då klass IIb.

2.4 Regel 8

Bröstimplantat tillhör klass III.

Alla övriga implantat och kirurgiska invasiva produkter som är avsedda för långvarig användning tillhör klass IIb, om de inte är avsedda

11. att sättas in i tänderna – de tillhör då klass IIa,
12. att användas i direkt kontakt med hjärtat, centrala cirkulationssystemet eller centrala nervsystemet – de tillhör då klass III,
13. att ha en biologisk verkan eller att helt eller till största delen absorberas – de tillhör då klass III eller
14. att genomgå en kemisk förändring i kroppen, utom om produkterna sätts in i tänderna, eller att administrera läkemedel – de tillhör då klass III.

3. Ytterligare bestämmelser för aktiva produkter

3.1 Regel 9

Alla aktiva terapeutiska produkter som är avsedda att tillföra eller utbyta energi tillhör klass IIa, om de inte har sådana egenskaper att de kan tillföra energi till eller utbyta energi med människokroppen på ett potentiellt farligt sätt, med tanke på energins egenskaper, täthet och platsen där energin skall användas – de tillhör då klass IIb.

Alla aktiva produkter som är avsedda att styra och/eller övervaka prestanda hos aktiva terapeutiska produkter i klass IIb eller är avsedda att direkt påverka sådana produkters prestanda tillhör klass IIb.

3.2 Regel 10

Aktiva produkter avsedda för diagnostik tillhör klass IIa

15. om de är avsedda att avge energi som kommer att absorberas av människokroppen, med undantag av produkter som används för att belysa patientens kropp i det synliga spektret.
16. om de är avsedda att avbilda spridningen av radiofarmaka i kroppen.
17. om de är avsedda att möjliggöra direkt diagnos eller övervakning av vitala fysiologiska processer, om produkterna inte är särskilt avsedda för att övervaka vitala fysiologiska variabler, vars variationer är sådana att de skulle kunna resultera i omedelbar fara för patienten, t. ex. variationer i hjärtverksamhet, andning eller det centrala nervsystemets aktivitet – de tillhör då klass IIb.

Aktiva produkter som är avsedda att avge joniserande strålning och avsedda för diagnostik och behandlande interventionell radiologi, inklusive produkter som styr och/eller övervakar sådana produkter eller som direkt påverkar deras prestanda, tillhör klass IIb.

Regel 11

Alla aktiva produkter som är avsedda att administrera eller avlägsna läkemedel, kroppsvätskor eller andra ämnen till eller från kroppen tillhör klass IIa, om det inte görs på ett sätt som är potentiellt skadligt med tanke på de aktuella ämnenas egenskaper, den kroppsdel och det användningssätt det är fråga om – de tillhör då klass IIb.

3.3 Regel 12

Alla andra aktiva produkter tillhör klass I.

4. SÄRSKILDA REGLER

4.1 Regel 13

Alla produkter i vilka ett ämne är integrerat, som om det används separat, kan betraktas som ett läkemedel enligt definitionen i 1 § läkemedelslagen (1992:859) och som kan ha en verkan på människokroppen som understödjer produkten, tillhör klass III. Alla produkter vilka som en integrerad del innehåller ett ämne som härrör från blod från människa tillhör klass III.

4.2 Regel 14

Alla produkter som används som preventivmedel eller för att förhindra spridningen av sexuellt överförbara sjukdomar tillhör klass IIb, om de inte är implantat eller invasiva produkter för långvarig användning – de tillhör då klass III.

4.3 Regel 15

Alla produkter som är särskilt avsedda för att desinficera medicintekniska produkter tillhör klass IIa.
Alla produkter som är särskilt avsedda för att desinficera, rengöra, skölja eller i förekommande fall för att hydratisera kontaktlinser tillhör klass IIb. Denna regel gäller inte produkter som är avsedda för att genom en fysisk insats rengöra andra medicintekniska produkter än kontaktlinser.

4.4 Regel 16

Icke aktiva produkter som är särskilt avsedda att lagra diagnostiska röntgenbilder tillhör klass IIa.

4.5 Regel 17

Alla produkter som tillverkas med hjälp av icke viabla djurvävnader eller produkter som kommer av sådana vävnader tillhör klass III, utom när sådana produkter är avsedda att bara komma i kontakt med intakt hud.

5 Regel 18

Blodpåsar tillhör klass IIb.

LAG (1992:1514) OM MÅTTENHETER, MÄTNINGAR & MÄTDON

SFS nr: 1992:1514

Departement/myndighet: Näringsdepartementet

Utfärdad: 1992-12-17

Ändrad: t.o.m. SFS 1995:1726

ANVÄNDNING AV VISSA MÅTTENHETER

1 §

För att uppfylla Sveriges åtaganden enligt avtalet om Europeiska ekonomiska samarbetsområdet (EES-avtalet) skall vad som sägs i denna paragraf gälla vid mätningar, som görs i ekonomiskt, hälsovårdande, skyddande eller administrativt syfte. Vid mätningar som avses i första stycket skall mätdonen, enligt närmare föreskrifter av regeringen eller den myndighet som regeringen bestämmer, vara graderade i och mätresultaten uttryckta i

1. måttenheter, som ingår i det internationella måttenhetssystem (SI-systemet) som har antagits av Allmänna konferensen för mått och vikt,
1. måttenheter, som har tillåtits för bruk tillsammans med SI-enheter enligt beslut av Internationella kommittén för mått och vikt, eller
2. andra särskilda måttenheter, som får användas enligt Sveriges åtaganden enligt EES-avtalet.

Regeringen eller den myndighet som regeringen bestämmer får i fråga om kommunikationer föreskriva om undantag från andra stycket, om det är förenligt med Sveriges åtaganden enligt EES-avtalet.

BEMYNDIGANDEN ATT MEDDELA FÖRESKRIFTER OM MÄTNINGAR M. M.

2 §

För att uppfylla Sveriges internationella överenskommelser eller om det är befogat från konsumentsynpunkt får regeringen eller den myndighet som regeringen bestämmer meddela föreskrifter om

- krav på mätningar och mättekniska metoder, och
- krav på och kontroll av mätdon, om föreskriften avser skydd för liv, personlig säkerhet eller hälsa, kommunikationer eller näringsverksamhet. Lag (1993:1380).

3 §

Regeringen eller den myndighet som regeringen bestämmer får också
meddela föreskrifter om

- krav på och kontroll av förpackningsstorlek och kontroll av mängduppgifter på färdigförpackade varor samt
- krav i fråga om särskild kundvåg i detaljhandeln.

TILLSYN

4 §

Tillsyn över efterlevnaden av denna lag och föreskrifter meddelade med stöd av lagen utövas för visst område av den myndighet som regeringen bestämmer.

5 §

Tillsynsmyndigheten har rätt att få tillträde till områden och lokaler där mätdon finns eller varor förpackas, förvaras eller säljs. Detsamma gäller den som svarar för kontroll som avses i 3 §.

Den hos vilken kontroll eller tillsyn sker är skyldig att underlätta tillsynsmyndighetens arbete.

Tillsynsmyndigheten eller den som svarar för kontroll enligt 3 § har rätt att få handräckning av kronofogdemyndigheten för att genomföra åtgärd som avses i första stycket.

6 §

En tillsynsmyndighet får meddela de förelägganden och förbud som behövs i en skilda fall för att denna lag eller föreskrifter meddelade med stöd av lagen skall efterlevas. Ett sådant föreläggande eller förbud får förenas med vite.

ÖVERKLAGANDE

7 §

En tillsynsmyndighets beslut enligt denna lag eller enligt föreskrifter som har meddelats med stöd av lagen får överklagas hos allmän förvaltningsdomstol. Prövningstillstånd krävs vid överklagande till kammarrätten. Lag (1995:1726).

ÖVERGÅNGSBESTÄMMELSER

1995:1726

Denna lag träder i kraft den 1 maj 1996 men tillämpas inte i de fall där det första beslutet i ärendet fattats dessförinnan.

APPENDIX C

KRAVSPECIFIKATION VERSION 1

MedTech – MF2003
2008-05-13

KRAVSPECIFIKATION VERSION 1

This specification of demands is written and handed out by Anders Fagergren.

SKALL-KRAV

Apparaten skall vrida handen uppåt 50 grader.

Två hastigheter 5°/s samt 240°/s skall användas.

Hastighetens stigtid skall vara <10 ms under normal belastning.

Apparaten ska kunna utföra vridningen ett valbart antal gånger i följd med en vilotid i extenderat läge på 1 s innan den återgår till startläge.

Apparaten ska ha ett justerbart rörelseomfång inom ±40° från ett läge där handen är parallell med underarmen.

Apparaten ska mäta moment, hastighet och tid under hela rörelsen.

Samplingsfrekvens på minst 100Hz för 236°/s och minst 10Hz för 5°/s, för hela rörelsen inklusive vilotiden. Det första samplet får ej innehålla rörelse, detta för att kunna användas som offsetvärde.

Momentet ska mätas i ett område 0-10 Nm med en noggrannhet på 0,05 Nm.

Apparaten ska räkna ut och presentera värdena på peak 1 och peak 2 samt peak 3.

Apparaten ska kunna göra mätningar på vuxna individer i sittande ställning.

Apparaten ska vara utformad så att mätningar är möjliga på både höger och vänster hand.

Handen och underarmen ska fästas proximalt och distalt i apparaten.

Maskinoperatören ska kunna se underarmen på patienten.

Apparaten ska vara bärbar.

Apparaten ska konstrueras enligt gällande normer för sjukhusutrustning och patientsäkerhet.

Apparatens mjukvara ska kunna uppdateras.

Apparaten ska kunna föra över mätdata till extern Windows-PC för presentation och vidare bearbetning.

Windows-programmet skall kunna uppdateras (källkod och utv. miljö).

Data skall sparas i text-filer så att kolumnerna är Tid, Moment och Hastighet, och raderna är sampel.

BÖR-KRAV

Apparaten bör klara fler hastigheter än 5°/s och 240°/s.

Apparaten bör klara mätningar på barn.

Apparatens uppdateringsprogramvara bör ha ett grafiskt användargränssnitt.

Apparaten skall vara billig att producera, mindre än 5000:- i komponenter + material.

APPENDIX D

ELECTRICAL SCHEMATICS, BOM's & PCB LAYOUTS

MedTech – MF2003
2008-05-13

ELECTRICAL SCHEMATICS, BOM'S & PCB LAYOUTS

BILL OF MATERIAL – BOM

SENSOR BOARD

Part	Value	Device	Package	Library
C1	100nF	C5/2.5	C5B2.5	capacitor-wima
C2	100nF	C5/2.5	C5B2.5	capacitor-wima
C3	100nF	C5/2.5	C5B2.5	capacitor-wima
C4	330nF	C5/2.5	C5B2.5	capacitor-wima
C5	1uF	C5/2.5	C5B2.5	capacitor-wima
C6	1uF	C5/2.5	C5B2.5	capacitor-wima
C7	100nF	C5/2.5	C5B2.5	capacitor-wima
C8	100nF	C5/2.5	C5B2.5	capacitor-wima
D1	1N5400	1N5400	DO201-15	diode
D2	1N5400	1N5400	DO201-15	diode
D3	1N5400	1N5400	DO201-15	diode
D4	1N5400	1N5400	DO201-15	diode
IC2	LM324P	LM324P	DIL14	lm324
IC3	7805T	7805T	TO220H	linear
INA111AP	AD620	AD620	DIL8	ad620
R1	182ohm	R-EU_0411/12	0411/12	rcl
R3	2,6k	R-EU_0411/12	0411/12	rcl
R4	10k	R-EU_0411/12	0411/12	rcl
R5	10k	R-EU_0411/12	0411/12	rcl
R6	1M	R-EU_0411/12	0411/12	rcl
R7	1M	R-EU_0411/12	0411/12	rcl
R8	2,6k	R-EU_0411/12	0411/12	rcl
R9	2,6k	R-EU_0411/12	0411/12	rcl
R10		TRIM_EU-PT10	PT-10	pot
R11	120ohm	R-EU_0411/12	0411/12	rcl
R12	120ohm	R-EU_0411/12	0411/12	rcl
SV1		MA04-1	MA04-1	con-lstb
SV2		MA03-1	MA03-1	con-lstb
SV3		MA05-2	MA05-2	con-lstb
SV4		MA05-2	MA05-2	con-lstb
SV5		MA03-1	MA03-1	con-lstb

12V Power Supply Board

Part	Value	Device	Package	Library
2KBP01		2KBP	2KBP	rectifier
2KBP02		2KBP	2KBP	rectifier
7912T		7912T	TO220H	linear
C1	1000uF	C5/5	C5B5	capacitor-wima
C2	330nF	C5/3	C5B3	capacitor-wima
C3	330nF	C5/3	C5B3	capacitor-wima
C4	100nF	C5/3	C5B3	capacitor-wima
C5	100nF	C5/3	C5B3	capacitor-wima
C6	1000uF	C5/5	C5B5	capacitor-wima
EI542B		EI54-2B	EI54-2B	trafo
FUSE		SH32	SH32	fuse
IC2	7812T	7812T	TO220H	linear
J1	DCJ0202	DCJ0202	DCJ0202	con-jack
SV2		MA03-1	MA03-1	con-lstb
X1		AK300/2	AK300/2	con-ptr500

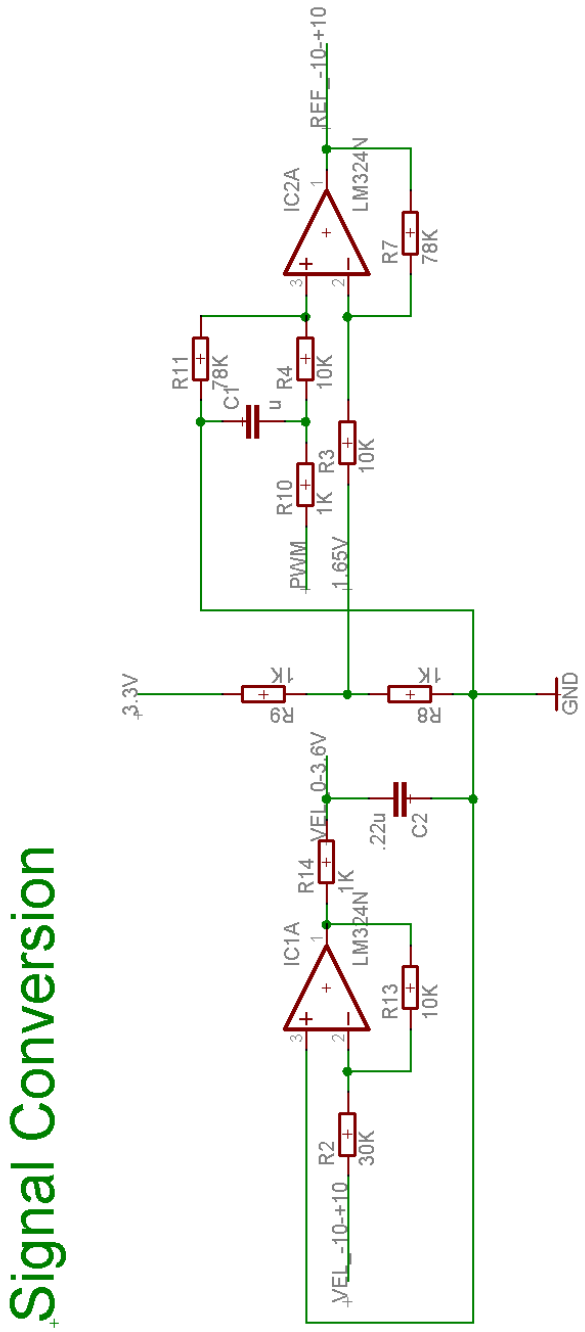
Signal Level Regulator Board

Part	Value	Device	Package	Library
R1	4.7k	R-EU_0207/10	0207/10	rcl
R2	3.3k	R-EU_0207/10	0207/10	rcl
R3	4.7k	R-EU_0207/10	0207/10	rcl
R4	3.3k	R-EU_0207/10	0207/10	rcl
SV1		MA04-1	MA04-1	con-lstb
SV2		MA04-1	MA04-1	con-lstb

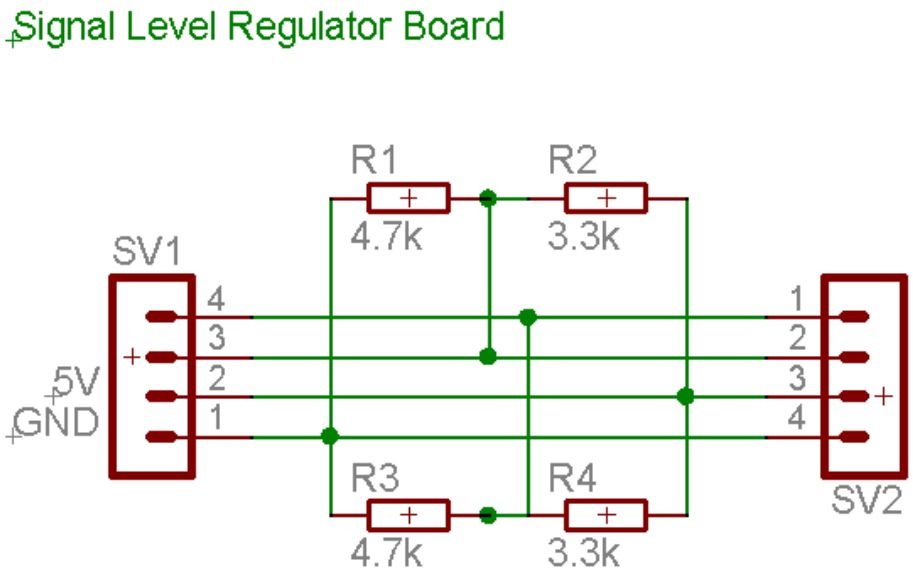
Amplifier Board

Part	Value	Device	Package	Library
C1	1u	C5/3	C5B3	capacitor-wima
C2	.22u	C5/3	C5B3	capacitor-wima
IC1	LM324N	LM324N	DIL14	linear
IC2	LM324N	LM324N	DIL14	linear
R2	30K	R-EU_0204/5	0204/5	rcl
R3	10K	R-EU_0204/5	0204/5	rcl
R4	10K	R-EU_0204/5	0204/5	rcl
R7	78K	R-EU_0204/5	0204/5	rcl
R8	1K	R-EU_0204/5	0204/5	rcl
R9	1K	R-EU_0204/5	0204/5	rcl
R10	1K	R-EU_0204/5	0204/5	rcl
R11	78K	R-EU_0204/5	0204/5	rcl
R13	10K	R-EU_0204/5	0204/5	rcl
R14	1K	R-EU_0204/5	0204/5	rcl

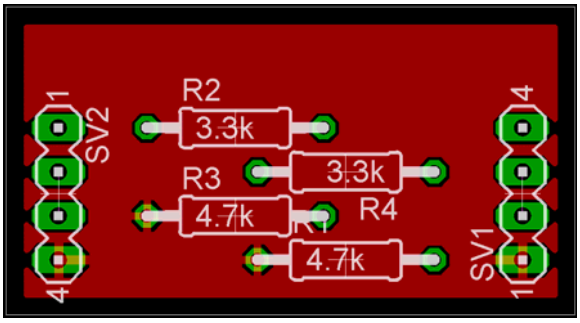
AMPLIFIER BOARD



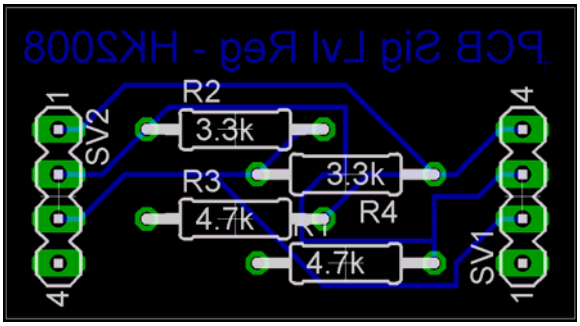
Signal Level Regulator Board



TOP LAYER

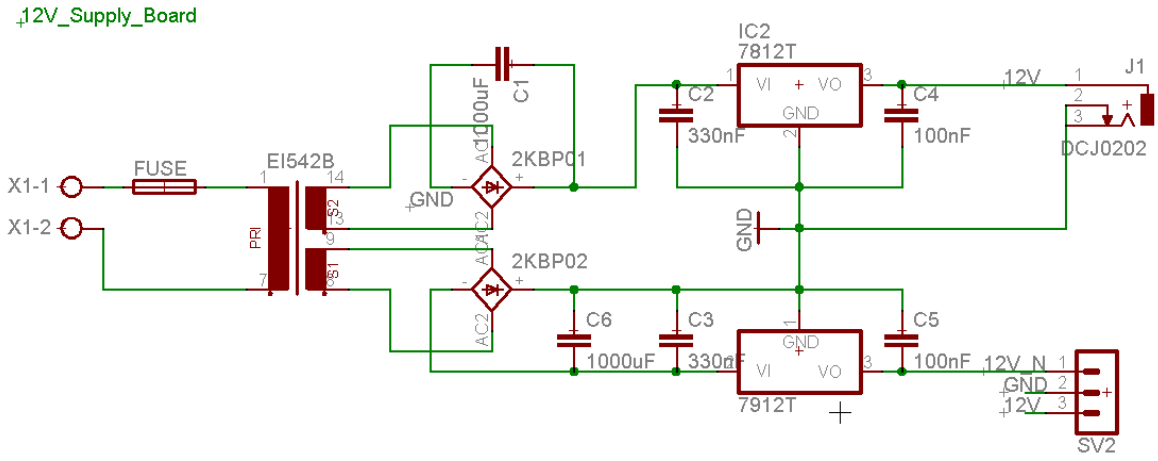


BOTTOM LAYER

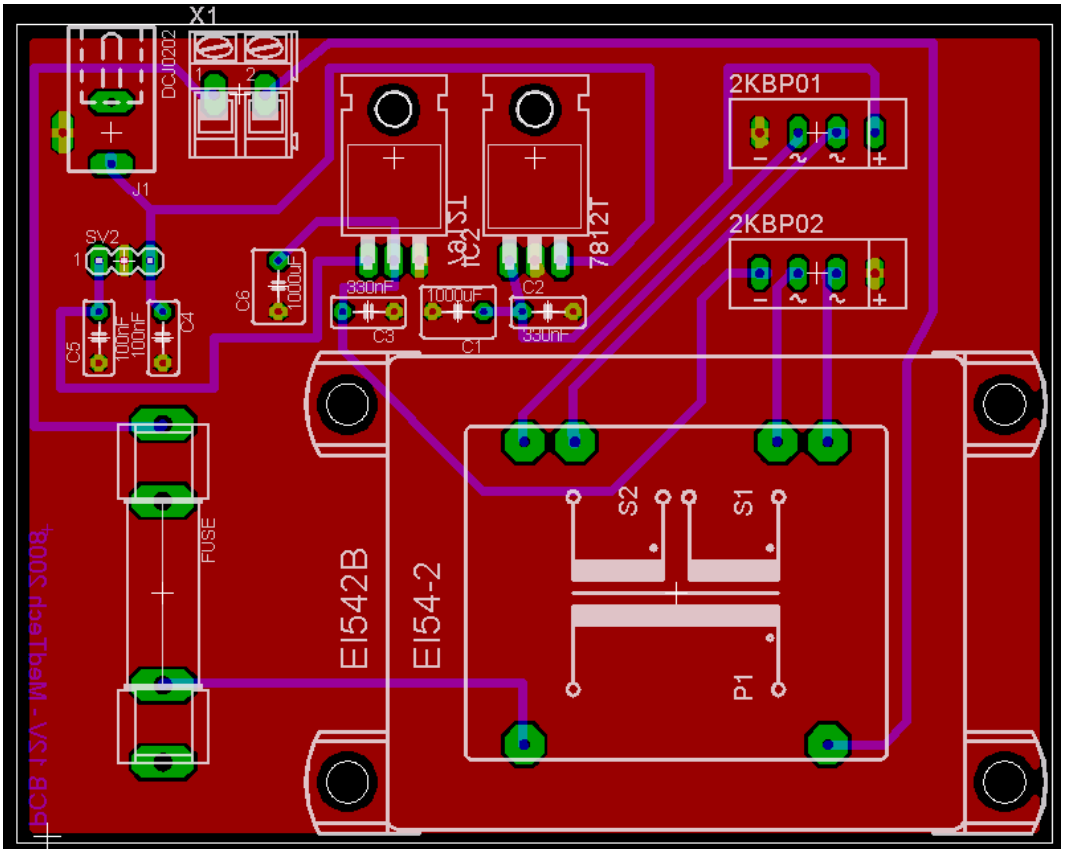


12V POWER SUPPLY BOARD

SCHEMATICS



TOP LAYER



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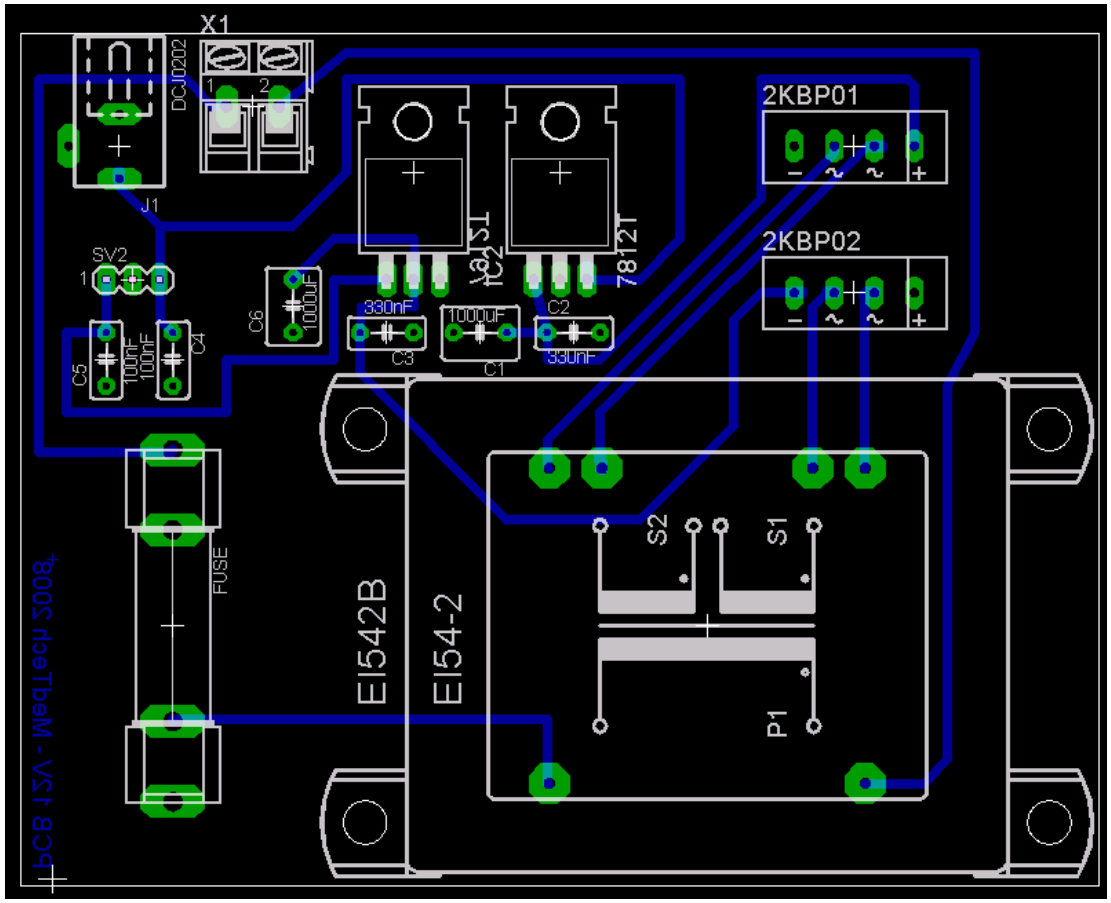
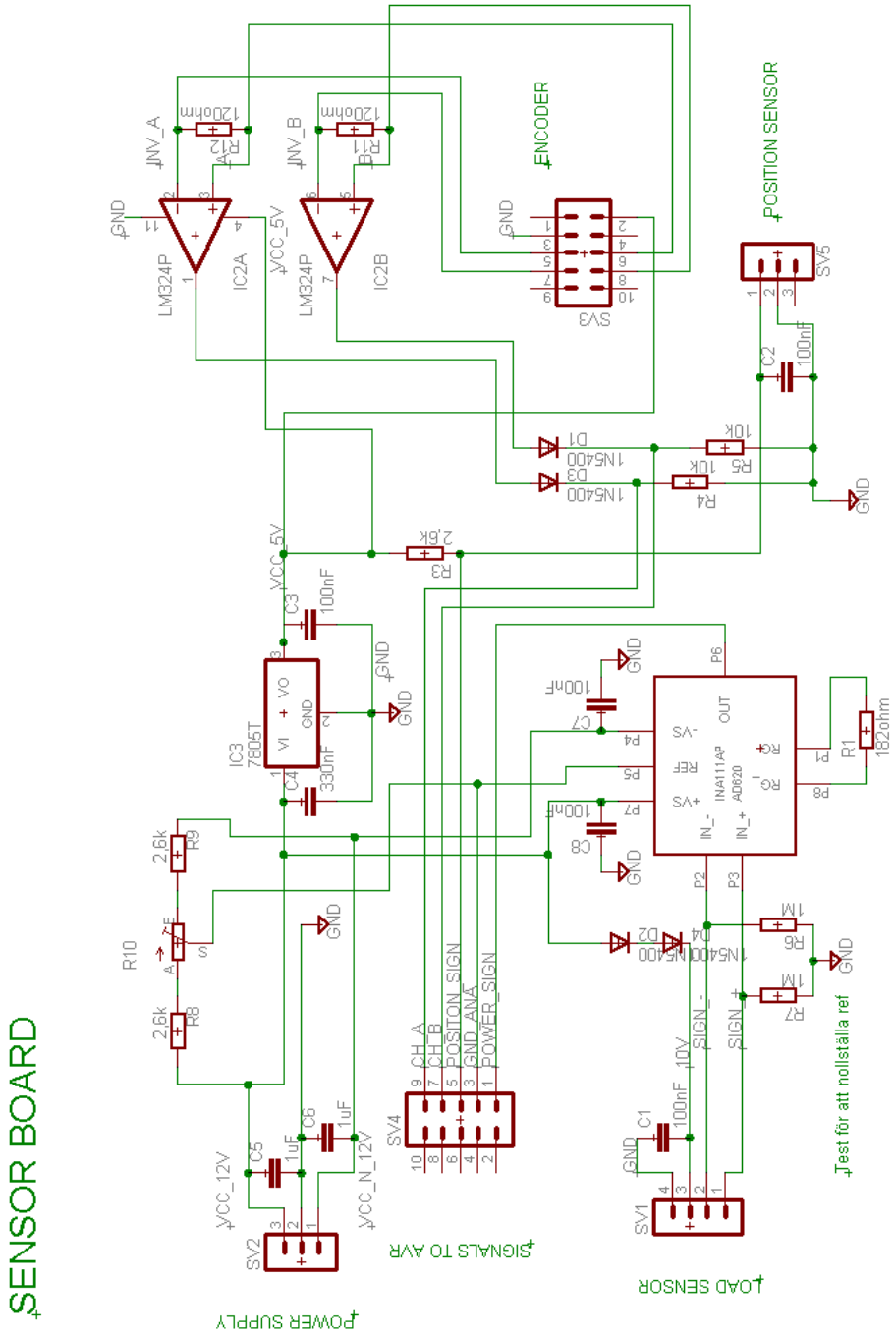
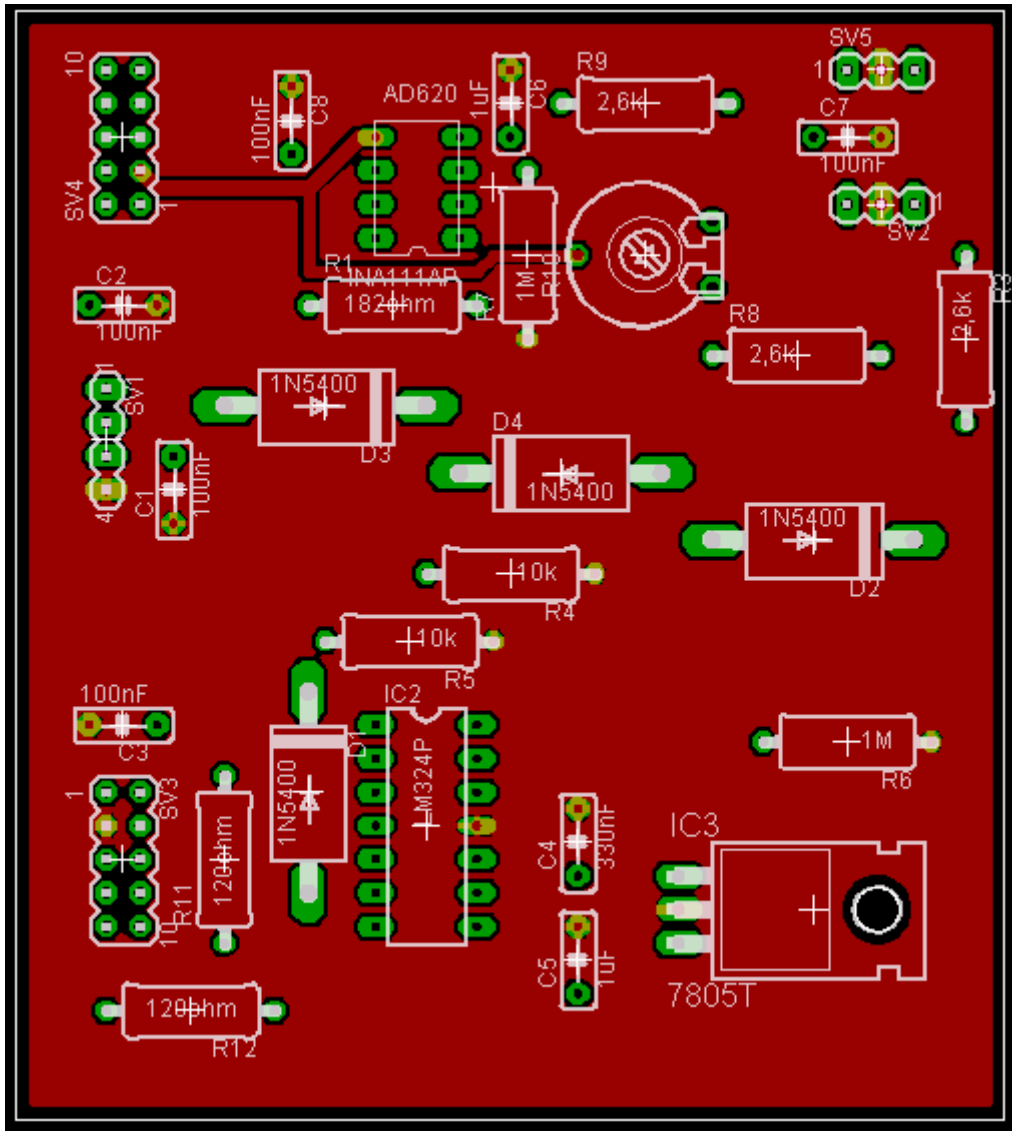


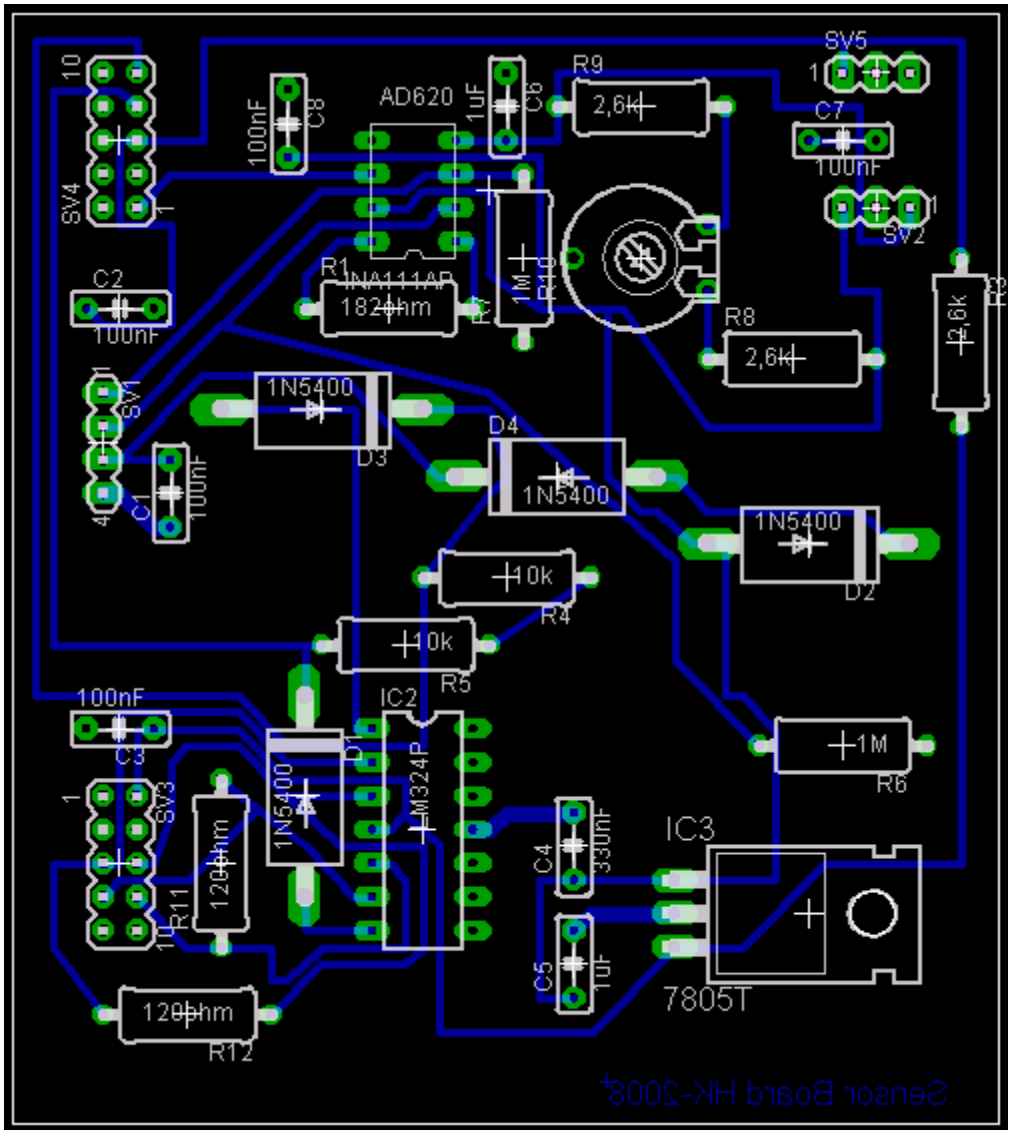
SENSOR BOARD



TOP LAYER


SV4
10
1
100nF
C8
AD620
1UF
C6
R9
2,6k
SV5
1
C7
100nF
SV2
1
C2
100nF
R1
INA111AP
182ohm
1M
R10
R8
2,6k
2,6k
SV1
1
4
C1
100nF
1N5400
D3
D4
1N5400
1N5400
D2
10k
R4
10k
R5
100nF
C3
IC2
LM324P
1N5400
D1
1M
R6
SV3
1
10
R11
120ohm
C4
33UmF
IC3
C5
1UF
7805T
120ohm
R12

BOTTOM LAYER



APPENDIX E

ELECTRICAL COMPONENTS & SENSORS DATASHEETS

MedTech – MF2003
2008-05-14

12V POWER SUPPLY BOARD

MedTech – MF2003
2008-05-13

2002-03-26

PRODUKTINFORMATION

Vi reserverar oss mot fel samt förbehåller oss rätten till ändringar utan föregående meddelande

ELFA artikelnr

70-362-70 2KBP01 brygga 100V 2.0A
70-362-88 2KBP02 brygga 200V 2.0A
70-362-96 2KBP04 brygga 400V 2.0A
70-363-04 2KBP06 brygga 600V 2.0A
70-363-12 2KBP08 brygga 800V 2.0A
70-363-20 2KBP10 brygga 1000V 2.0A

INTERNATIONAL RECTIFIER IOR

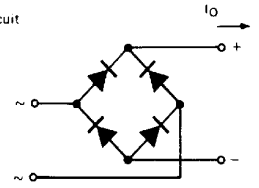
2KBP SERIES

2A single phase rectifier bridge

Maximum Ratings

		2KBP	Units
I_O		2.0	A
I_{FSM}	50Hz	60	A
	60Hz	63	A
I^2t	50Hz	18	A^2s
	60Hz	16	A^2s
V_{RRM}		50 to 1000	V

Circuit



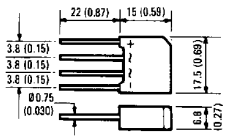
Description

A 2A single phase encapsulated bridge rectifier consisting of four single diodes connected as a full bridge. They are intended for general applications in industrial and consumer equipment.

Features

- *Suitable for printed circuit board mounting*
- *Compact construction*
- *High surge current capability*

Outline



All dimensions in millimetres (inches)

Electrical specifications

		2KBP	Units	Conditions
I_O	Maximum DC output current	2.0	A	T_{amb} = 50°C, Resistive or inductive load
		1.8	A	T_{amb} = 50°C, Capacitive load
I_{FSM}	Maximum peak one cycle, non-repetitive surge current	60	A	t = 10ms, 20ms — Following any rated load condition and with rated V_{RRM} reapplied
		63	A	t = 8.3ms, 16.7ms
I^2t	Maximum I^2t capability for fusing	18	A^2s	t = 10ms — Initial $T_J = T_J$ max, 100% V_{RRM} reapplied
		16	A^2s	t = 8.3ms
		26	A^2s	t = 10ms — Initial $T_J = T_J$ max, No voltage reapplied
		23	A^2s	t = 8.3ms
$I^2\sqrt{t}$	Maximum $I^2\sqrt{t}$ capability for fusing	255	$A^2\sqrt{s}$	t = 0.1 to 10ms, no voltage reapplied
V_{FM}	Maximum peak forward voltage per diode	1.0	V	I_{FM} = 1A, T_J = 25°C
I_{RM}	Typical peak reverse leakage current per diode	10	μA	T_J = 25°C — 100% V_{RRM}
		1.0	mA	T_J = 150°C
f	Operating frequency range	40 to 1000	Hz	

Thermal and mechanical specifications

		2KBP	Units	Conditions
T_J	Operating temperature range	−40 to 150	°C	
T_{stg}	Storage temperature range	−40 to 150	°C	
W	Approximate weight	4 (0.14)	g (oz)	

Voltage specifications

Part number	V_{RRM}. Maximum repetitive peak reverse voltage	V_{RSM}. Maximum non-repetitive peak reverse voltage	V_{RMS}. Maximum recommended RMS supply voltage
	V	V	V
2KBP005	50	50	20
2KBP02	200	200	80
2KBP04	400	400	125
2KBP06	600	600	250
2KBP08	800	800	380
2KBP10	1000	1000	500

Fig. 1 – Ambient Temperature Ratings

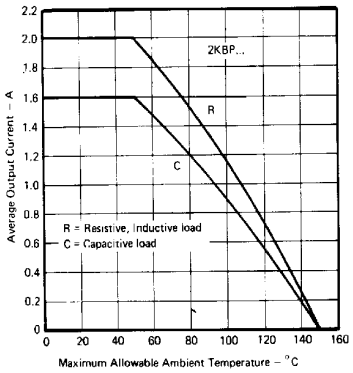
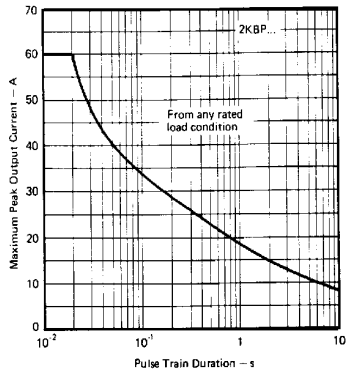


Fig. 2 – Non-Repetitive Surge Ratings



ELFA

Datum 980914

PRODUKTINFORMATION

TEKNISK INFORMATION 020-75 80 20 ORDERTEL 020-75 80 00 ORDERFAX 020-75 80 10
TECHNICAL INFORMATION +46 8 580 941 15 ORDERPHONE +46 8 580 941 01 ORDERFAX +46 8 580 941 11
Vi reserverar oss mot fel samt förbehåller oss rätten till ändringar utan föregående meddelande

ELFA artikelnr.

Antal sidor: 18

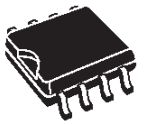
73-264-08 78L05ACZ 5V 0,1 Sp reg
73-264-16 78L06ACZ 6V 0,1 Sp reg
73-264-24 78L08ACZ 8V 0,1 Sp reg
73-264-32 78L09ACZ 9V 0,1 Sp reg
73-264-40 78L12ACZ 12V 0,1 Sp reg
73-264-57 78L15ACZ 15V 0,1 Sp reg
73-264-65 78L18ACZ 18V 0,1 Sp reg
73-264-73 78L24ACZ 24V 0,1 Sp reg

SGS-THOMSON MICROELECTRONICS

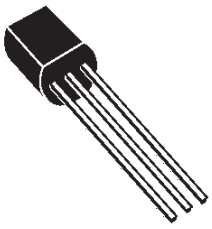
L78L00 SERIES

POSITIVE VOLTAGE REGULATORS

- OUTPUT CURRENT UP TO 100 mA
- OUTPUT VOLTAGES OF 3.3; 5; 6; 8; 9; 12; 15; 18; 24V
- THERMAL OVERLOAD PROTECTION
- SHORT CIRCUIT PROTECTION
- NO EXTERNAL COMPONENTS ARE REQUIRED
- AVAILABLE IN EITHER ± 5% (AC) OR ± 10% (C) SELECTION



SO-8



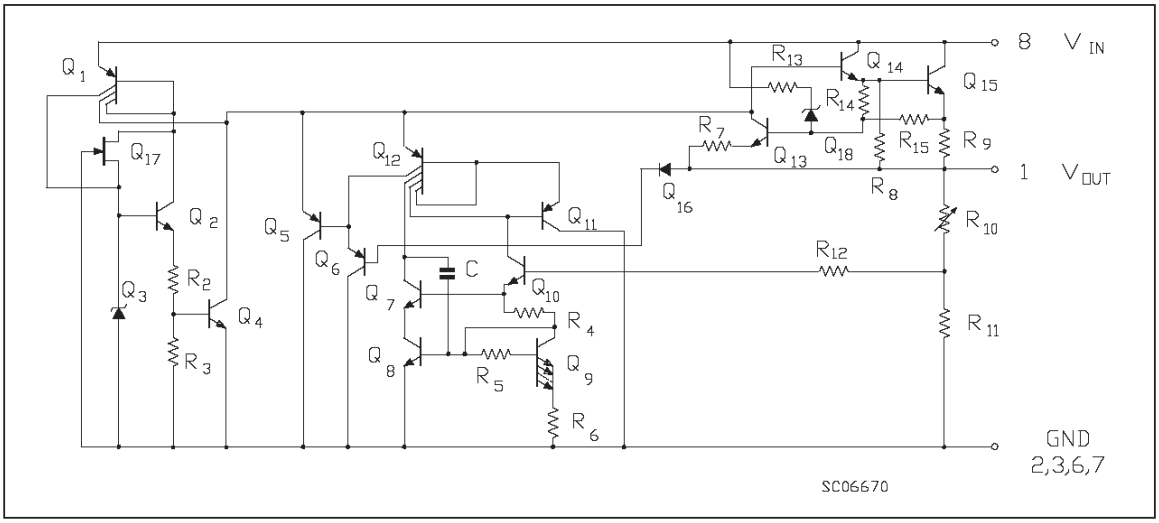
TO-92

DESCRIPTION

The L78L00 series of three-terminal positive regulators employ internal current limiting and thermal shutdown, making them essentially indestructible. If adequate heatsink is provided, they can deliver up to 100 mA output current. They are intended as fixed voltage regulators in a wide range of applications including local or on-card regulation for elimination of noise and distribution problems associated with single-point regulation. In addition, they can be used with power pass elements to make high-current voltage regulators.

The L78L00 series used as Zener diode/resistor combination replacement, offers an effective output impedance improvement of typically two orders of magnetude, along with lower quiescent current and lower noise.

BLOCK DIAGRAM

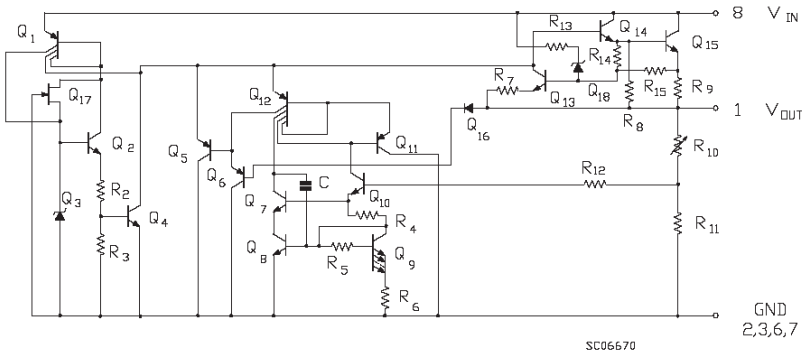


ABSOLUTE MAXIMUM RATING

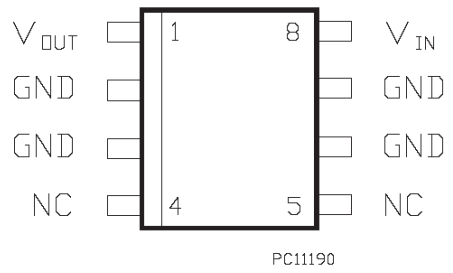
Symbol	Parameter		Value	Unit
V_i	DC Input Voltage	V_o = 3.3 V to 9 V	30	V
		V_o = 12 V to 15 V	35	V
		V_o = 18 V to 24 V	40	V
I_o	Output Current		100	mA
P_{tot}	Power Dissipation		Internally limited (*)	
T_{stg}	Storage Temperature Range		- 40 to 150	°C
T_{op}	Operating Junction Temperature RangeFor L78L00C, L78L00AC For L78L00AB		0 to 125 - 40 to 125	°C °C

(*) Our SO-8 package used for Voltage Regulators is modified internally to have pins 2, 3, 6 and 7 electrically commoned to the die attach flag. This particular frame decreases the total thermal resistance of the package and increases its ability to dissipate power when an appropriate area of copper on the printed circuit board is available for heatsinking. The external dimensions are the same as for the standard SO-8

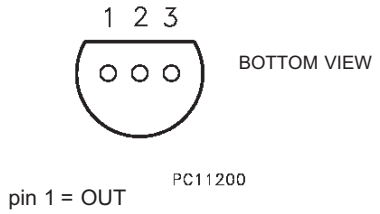
TEST CIRCUITS



CONNECTION DIAGRAM AND ORDERING NUMBERS (top view)



SO-8



TO-92

ORDERING NUMBERS

Type	SO-8	TO-92	Output Voltage
L78L33AC	L78L33ACD	L78L33ACZ	3.3 V
L78L33AB	L78L33ABD	L78L33ABZ	3.3 V
L78L05C	L78L05CD	L78L05CZ	5 V
L78L05AC	L78L05ACD	L78L05ACZ	5 V
L78L05AB	L78L05ABD	L78L05ABZ	5 V
L78L06C	L78L06CD	L78L06CZ	6 V
L78L06AC	L78L06ACD	L78L06ACZ	6 V
L78L06AB	L78L06ABD	L78L06ABZ	6 V
L78L08C	L78L08CD	L78L08CZ	8 V
L78L08AC	L78L08ACD	L78L08ACZ	8 V
L78L08AB	L78L08ABD	L78L08ABZ	8 V
L78L09C	L78L09CD	L78L09CZ	9 V
L78L09AC	L78L09ACD	L78L09ACZ	9 V
L78L09AB	L78L09ABD	L78L09ABZ	9 V
L78L12C	L78L12CD	L78L12CZ	12 V
L78L12AC	L78L12ACD	L78L12ACZ	12 V
L78L12AB	L78L12ABD	L78L12ABZ	12 V
L78L15C	L78L15CD	L78L15CZ	15 V
L78L15AC	L78L15ACD	L78L15ACZ	15 V
L78L15AB	L78L15ABD	L78L15ABZ	15 V
L78L18C	L78L18CD	L78L18CZ	18 V
L78L18AC	L78L18ACD	L78L18ACZ	18 V
L78L18AB	L78L18ABD	L78L18ABZ	18 V
L78L24C	L78L24CD	L78L24CZ	24 V
L78L24AC	L78L24ACD	L78L24ACZ	24 V
L78L24AB	L78L24ABD	L78L24ABZ	24 V

ELECTRICAL CHARACTERISTICS FOR L78L05 (refer to the test circuits, T_j = 0 to 125 °C, V_i = 10V, I_o = 40 mA, C_i = 0.33 µF, C_o = 0.1 µF unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 °C	4.6	5	5.4	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 7 to 20 V I_o = 1 to 70 mA V_i = 10 V	4.5 4.5		5.5 5.5	V V
ΔV_o	Line Regulation	V_i = 7 to 20 V T_j = 25 °C V_i = 8 to 20 V T_j = 25 °C			200 150	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 °C I_o = 1 to 40 mA T_j = 25 °C			60 30	mV mV
I_d	Quiescent Current	T_j = 25 °C T_j = 125 °C			6 5.5	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.2	mA
ΔI_d	Quiescent Current Change	V_i = 8 to 20 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 °C		40		µV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 °C V_i = 8 to 18 V	40	49		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L06 (refer to the test circuits, T_j = 0 to 125 °C, V_i = 12V, I_o = 40 mA, C_i = 0.33 µF, C_o = 0.1 µF unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 °C	5.52	6	6.48	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 8.5 to 20 V I_o = 1 to 70 mA V_i = 12 V	5.4 5.4		6.6 6.6	V V
ΔV_o	Line Regulation	V_i = 8.5 to 20 V T_j = 25 °C V_i = 9 to 20 V T_j = 25 °C			200 150	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 °C I_o = 1 to 40 mA T_j = 25 °C			60 30	mV mV
I_d	Quiescent Current	T_j = 25 °C T_j = 125 °C			6 5.5	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.2	mA
ΔI_d	Quiescent Current Change	V_i = 8 to 20 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 °C		50		µV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 °C V_i = 9 to 20 V	38	46		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L08 (refer to the test circuits, T_j = 0 to 125 °C, V_i = 14V, I_o = 40 mA, C_i = 0.33 µF, C_o = 0.1 µF unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 °C	7.36	8	8.64	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 10.5 to 23 V I_o = 1 to 70 mA V_i = 14 V	7.2 7.2		8.8 8.8	V V
ΔV_o	Line Regulation	V_i = 10.5 to 23 V T_j = 25 °C V_i = 11 to 23 V T_j = 25 °C			200 150	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 °C I_o = 1 to 40 mA T_j = 25 °C			80 40	mV mV
I_d	Quiescent Current	T_j = 25 °C T_j = 125 °C			6 5.5	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.2	mA
ΔI_d	Quiescent Current Change	V_i = 11 to 23 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 °C		60		µV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 °C V_i = 12 to 23 V	36	45		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L09 (refer to the test circuits, T_j = 0 to 125 °C, V_i = 15V, I_o = 40 mA, C_i = 0.33 µF, C_o = 0.1 µF unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 °C	8.28	9	9.72	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 11.5 to 23 V I_o = 1 to 70 mA V_i = 15 V	8.1 8.1		9.9 9.9	V V
ΔV_o	Line Regulation	V_i = 11.5 to 23 V T_j = 25 °C V_i = 12 to 23 V T_j = 25 °C			250 200	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 °C I_o = 1 to 40 mA T_j = 25 °C			80 40	mV mV
I_d	Quiescent Current	T_j = 25 °C T_j = 125 °C			6 5.5	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.2	mA
ΔI_d	Quiescent Current Change	V_i = 12 to 23 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 °C		70		µV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 °C V_i = 12 to 23 V	36	44		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L12 (refer to the test circuits, T_j = 0 to 125 °C, V_i = 19V, I_o = 40 mA, C_i = 0.33 µF, C_o = 0.1 µF unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 °C	11.1	12	12.9	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 14.5 to 27 V I_o = 1 to 70 mA V_i = 19 V	10.8 10.8		13.2 13.2	V V
ΔV_o	Line Regulation	V_i = 14.5 to 27 V T_j = 25 °C V_i = 16 to 27 V T_j = 25 °C			250 200	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 °C I_o = 1 to 40 mA T_j = 25 °C			100 50	mV mV
I_d	Quiescent Current	T_j = 25 °C T_j = 125 °C			6.5 6	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.2	mA
ΔI_d	Quiescent Current Change	V_i = 16 to 27 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 °C		80		µV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 °C V_i = 15 to 25 V	36	42		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L15 (refer to the test circuits, T_j = 0 to 125 °C, V_i = 23V, I_o = 40 mA, C_i = 0.33 µF, C_o = 0.1 µF unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 °C	13.8	15	16.2	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 17.5 to 30 V I_o = 1 to 70 mA V_i = 23 V	13.5 13.5		16.5 16.5	V V
ΔV_o	Line Regulation	V_i = 17.5 to 30 V T_j = 25 °C V_i = 20 to 30 V T_j = 25 °C			300 250	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 °C I_o = 1 to 40 mA T_j = 25 °C			150 75	mV mV
I_d	Quiescent Current	T_j = 25 °C T_j = 125 °C			6.5 6	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.2	mA
ΔI_d	Quiescent Current Change	V_i = 20 to 30 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 °C		90		µV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 °C V_i = 18.5 to 28.5 V	33	39		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L18 (refer to the test circuits, T_j = 0 to 125 °C, V_i = 27V, I_o = 40 mA, C_i = 0.33 µF, C_o = 0.1 µF unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 °C	16.6	18	19.4	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 22 to 33 V I_o = 1 to 70 mA V_i = 27 V	16.2 16.2		19.8 19.8	V V
ΔV_o	Line Regulation	V_i = 22 to 33 V T_j = 25 °C V_i = 22 to 33 V T_j = 25 °C			320 270	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 °C I_o = 1 to 40 mA T_j = 25 °C			170 85	mV mV
I_d	Quiescent Current	T_j = 25 °C T_j = 125 °C			6.5 6	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.2	mA
ΔI_d	Quiescent Current Change	V_i = 23 to 33 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 °C		120		µV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 °C V_i = 23 to 33 V	32	38		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L24 (refer to the test circuits, T_j = 0 to 125 °C, V_i = 33V, I_o = 40 mA, C_i = 0.33 µF, C_o = 0.1 µF unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 °C	22.1	24	25.9	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 27 to 38 V I_o = 1 to 70 mA V_i = 33 V	21.6 21.6		26.4 26.4	V V
ΔV_o	Line Regulation	V_i = 27 to 38 V T_j = 25 °C V_i = 28 to 38 V T_j = 25 °C			350 300	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 °C I_o = 1 to 40 mA T_j = 25 °C			200 100	mV mV
I_d	Quiescent Current	T_j = 25 °C T_j = 125 °C			6.5 6	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.2	mA
ΔI_d	Quiescent Current Change	V_i = 28 to 38 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 °C		200		µV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 °C V_i = 29 to 35 V	30	37		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L33AB AND L78L33AC

(refer to the test circuits, V_i = 8.3V, I_o = 40 mA, C_i = 0.33 µF, C_o = 0.1 µF, T_j = 0 to 125 °C for L78L33AC, T_j = -40 to 125 °C for L78L33AB, unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 °C	3.168	3.3	3.432	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 5.3 to 20 V I_o = 1 to 70 mA V_i = 8.3 V	3.135 3.135		3.465 3.465	V V
ΔV_o	Line Regulation	V_i = 5.3 to 20 V T_j = 25 °C V_i = 6.3 to 20 V T_j = 25 °C			150 100	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 °C I_o = 1 to 40 mA T_j = 25 °C			60 30	mV mV
I_d	Quiescent Current	T_j = 25 °C T_j = 125 °C			6 5.5	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.1	mA
ΔI_d	Quiescent Current Change	V_i = 6.3 to 20 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 °C		40		µV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 °C V_i = 6.3 to 16.3 V	41	49		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L05AB AND L78L05AC

(refer to the test circuits, V_i = 10V, I_o = 40 mA, C_i = 0.33 µF, C_o = 0.1 µF, T_j = 0 to 125 °C for L78L05AC, T_j = -40 to 125 °C for L78L05AB, unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 °C	4.8	5	5.2	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 7 to 20 V I_o = 1 to 70 mA V_i = 10 V	4.75 4.75		5.25 5.25	V V
ΔV_o	Line Regulation	V_i = 7 to 20 V T_j = 25 °C V_i = 8 to 20 V T_j = 25 °C			150 100	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 °C I_o = 1 to 40 mA T_j = 25 °C			60 30	mV mV
I_d	Quiescent Current	T_j = 25 °C T_j = 125 °C			6 5.5	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.1	mA
ΔI_d	Quiescent Current Change	V_i = 8 to 20 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 °C		40		µV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 °C V_i = 8 to 18 V	41	49		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L06AB AND L78L06AC

(refer to the test circuits, V_i = 12V, I_o = 40 mA, C_i = 0.33 µF, C_o = 0.1 µF,
T_j = 0 to 125 °C for L78L06AC, T_j = -40 to 125 °C for L78L06AB, unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 °C	5.76	6	6.24	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 8.5 to 20 V I_o = 1 to 70 mA V_i = 12 V	5.7 5.7		6.3 6.3	V V
ΔV_o	Line Regulation	V_i = 8.5 to 20 V T_j = 25 °C V_i = 9 to 20 V T_j = 25 °C			150 100	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 °C I_o = 1 to 40 mA T_j = 25 °C			60 30	mV mV
I_d	Quiescent Current	T_j = 25 °C T_j = 125 °C			6 5.5	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.1	mA
ΔI_d	Quiescent Current Change	V_i = 9 to 20 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 °C		50		µV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 °C V_i = 9 to 20 V	39	46		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L12AB AND L78L12AC

(refer to the test circuits, V_i = 19V, I_o = 40 mA, C_i = 0.33 µF, C_o = 0.1 µF,
T_j = 0 to 125 °C for L78L12AC, T_j = -40 to 125 °C for L78L12AB, unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 °C	11.5	12	12.5	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 14.5 to 27 V I_o = 1 to 70 mA V_i = 19 V	11.4 11.4		12.6 12.6	V V
ΔV_o	Line Regulation	V_i = 14.5 to 27 V T_j = 25 °C V_i = 16 to 27 V T_j = 25 °C			250 200	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 °C I_o = 1 to 40 mA T_j = 25 °C			100 50	mV mV
I_d	Quiescent Current	T_j = 25 °C T_j = 125 °C			6.5 6	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.1	mA
ΔI_d	Quiescent Current Change	V_i = 16 to 27 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 °C		80		µV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 °C V_i = 15 to 25 V	37	42		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L15AB AND L78L15AC

(refer to the test circuits, V_i = 23V, I_o = 40 mA, C_i = 0.33 µF, C_o = 0.1 µF,
T_j = 0 to 125 °C for L78L15AC, T_j = -40 to 125 °C for L78L15AB, unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 °C	14.4	15	15.6	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 17.5 to 30 V I_o = 1 to 70 mA V_i = 23 V	14.25 14.25		15.75 15.75	V V
ΔV_o	Line Regulation	V_i = 17.5 to 30 V T_j = 25 °C V_i = 20 to 30 V T_j = 25 °C			300 250	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 °C I_o = 1 to 40 mA T_j = 25 °C			150 75	mV mV
I_d	Quiescent Current	T_j = 25 °C T_j = 125 °C			6.5 6	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.1	mA
ΔI_d	Quiescent Current Change	V_i = 20 to 30 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 °C		90		µV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 °C V_i = 18.5 to 28.5 V	34	39		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L18AB AND L78L18AC

(refer to the test circuits, V_i = 27V, I_o = 40 mA, C_i = 0.33 µF, C_o = 0.1 µF,
T_j = 0 to 125 °C for L78L18AC, T_j = -40 to 125 °C for L78L18AB, unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 °C	17.3	18	18.7	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 22 to 33 V I_o = 1 to 70 mA V_i = 27 V	17.1 17.1		18.9 18.9	V V
ΔV_o	Line Regulation	V_i = 22 to 33 V T_j = 25 °C V_i = 22 to 33 V T_j = 25 °C			320 270	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 °C I_o = 1 to 40 mA T_j = 25 °C			170 85	mV mV
I_d	Quiescent Current	T_j = 25 °C T_j = 125 °C			6.5 6	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.1	mA
ΔI_d	Quiescent Current Change	V_i = 23 to 33 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 °C		120		µV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 °C V_i = 23 to 33 V	33	38		dB
V_d	Dropout Voltage			1.7		V

ELECTRICAL CHARACTERISTICS FOR L78L24AB AND L78L24AC

(refer to the test circuits, V_i = 33V, I_o = 40 mA, C_i = 0.33 µF, C_o = 0.1 µF, T_j = 0 to 125 °C for L78L24AC, T_j = -40 to 125 °C for L78L24AB, unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
V_o	Output Voltage	T_j = 25 °C	23	24	25	V
V_o	Output Voltage	I_o = 1 to 40 mA V_i = 27 to 38 V I_o = 1 to 70 mA V_i = 33 V	22.8 22.8		25.2 25.2	V V
ΔV_o	Line Regulation	V_i = 27 to 38 V T_j = 25 °C V_i = 28 to 38 V T_j = 25 °C			350 300	mV mV
ΔV_o	Load Regulation	I_o = 1 to 100 mA T_j = 25 °C I_o = 1 to 40 mA T_j = 25 °C			200 100	mV mV
I_d	Quiescent Current	T_j = 25 °C T_j = 125 °C			6.5 6	mA mA
ΔI_d	Quiescent Current Change	I_o = 1 to 40 mA			0.1	mA
ΔI_d	Quiescent Current Change	V_i = 28 to 38 V			1.5	mA
eN	Output Noise Voltage	B = 10Hz to 100KHz T_j = 25 °C		200		µV
SVR	Supply Voltage Rejection	I_o = 40 mA f = 120 Hz T_j = 25 °C V_i = 29 to 35 V	31	37		dB
V_d	Dropout Voltage			1.7		V

Figure 1: L78L05/12 Output Voltage vs Ambient Temperature

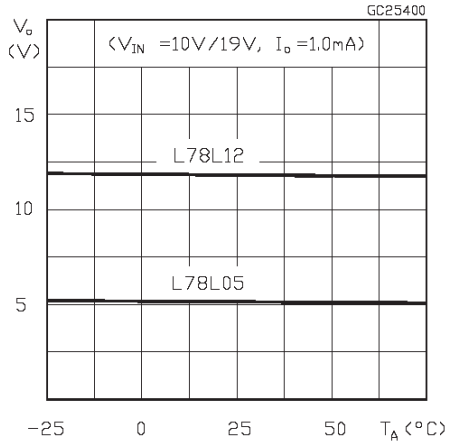


Figure 2 : L78L05/12/24 Load Characteristics.

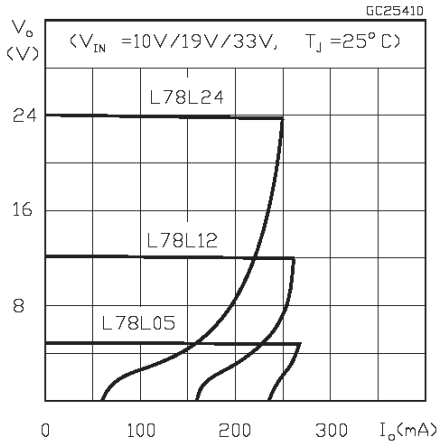


Figure 3 : L78L05/12/24 Thermal Shutdown.

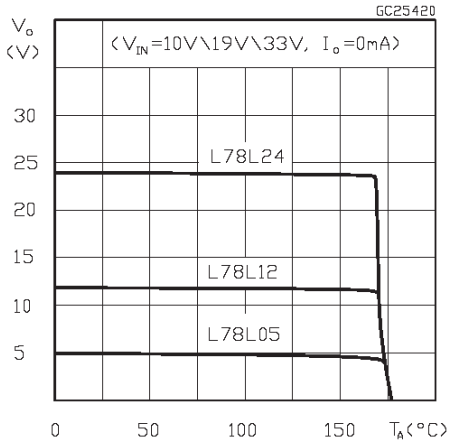


Figure 4 : L78L05/12 Quiescent Current vs Output Current

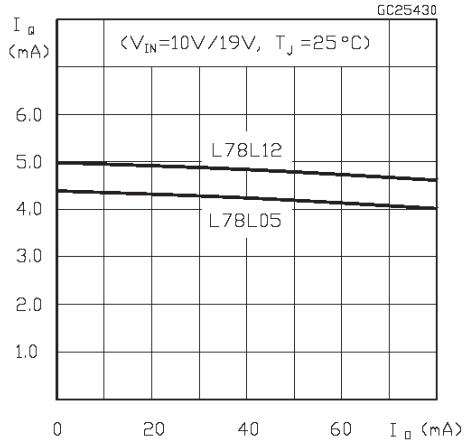


Figure 5 : L78L05 Quiescent Current vs Input Voltage.

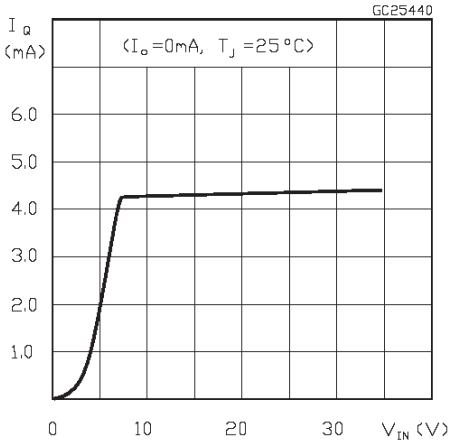


Figure 6 : L78L05/12/24 Output Characteristics.

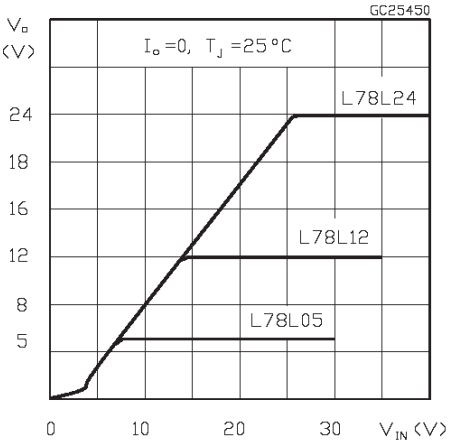


Figure 7 : L78L05/12/24 Ripple Rejection.

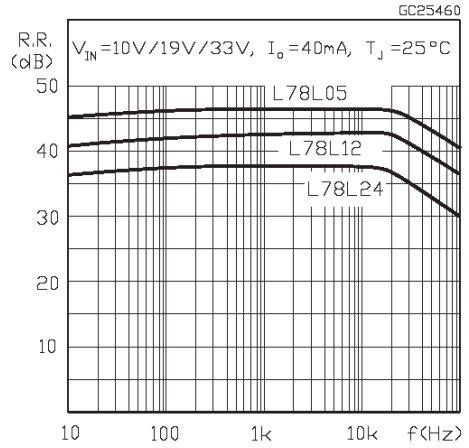


Figure 8 : L78L05 Dropout Characteristics.

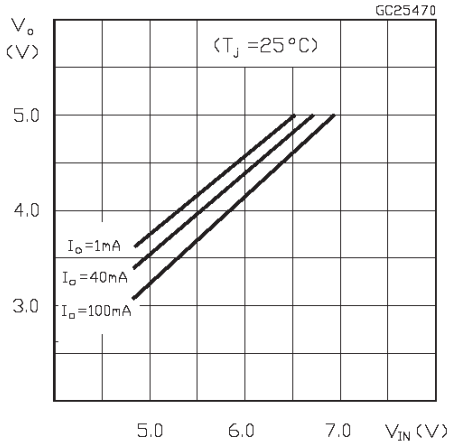
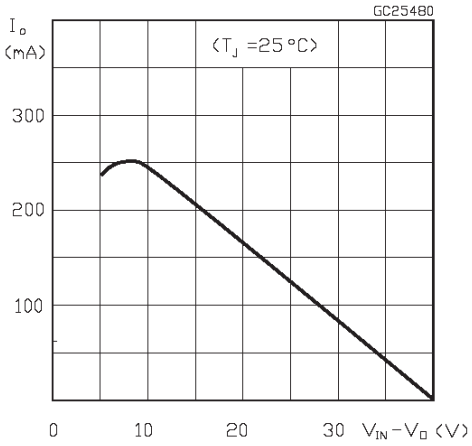


Figure 9 : L78L00 Series Short Circuit Output Current.



TYPICAL APPLICATIONS:

Figure 10: High Output Current Short Circuit Protected

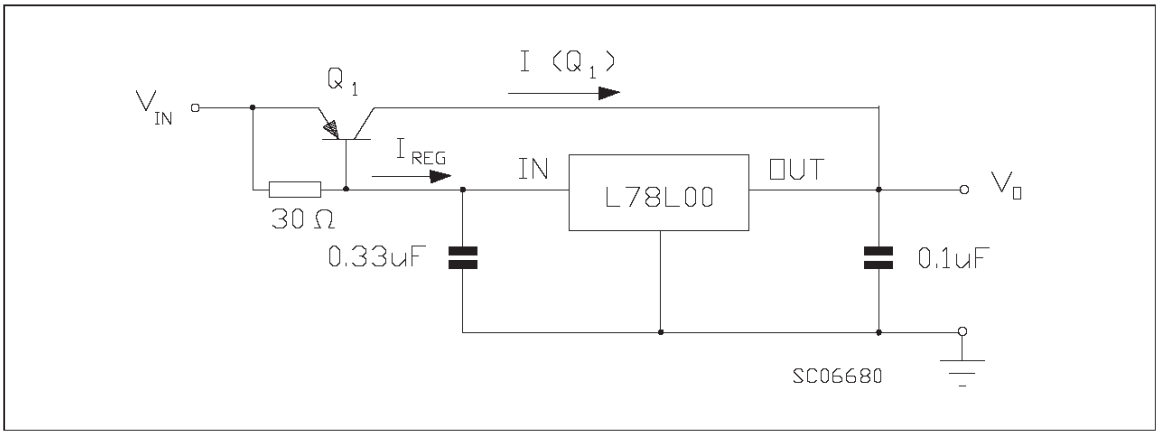


Figure 11 : Output Boost Circuit.

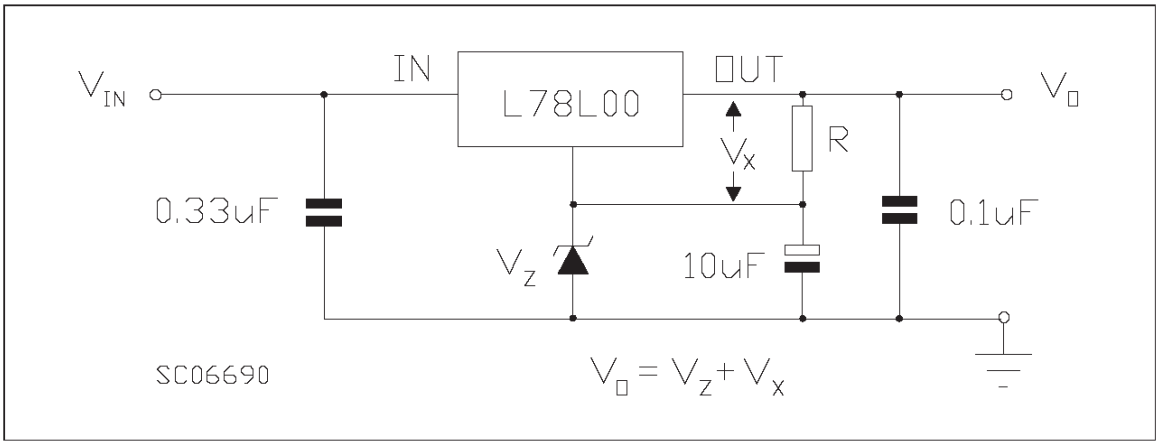


Figure 12 : Current Regulator.

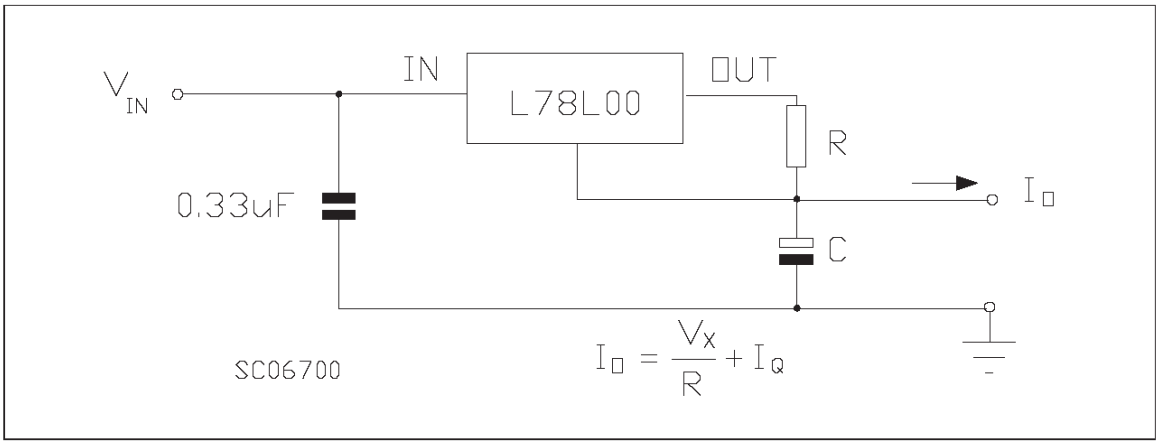
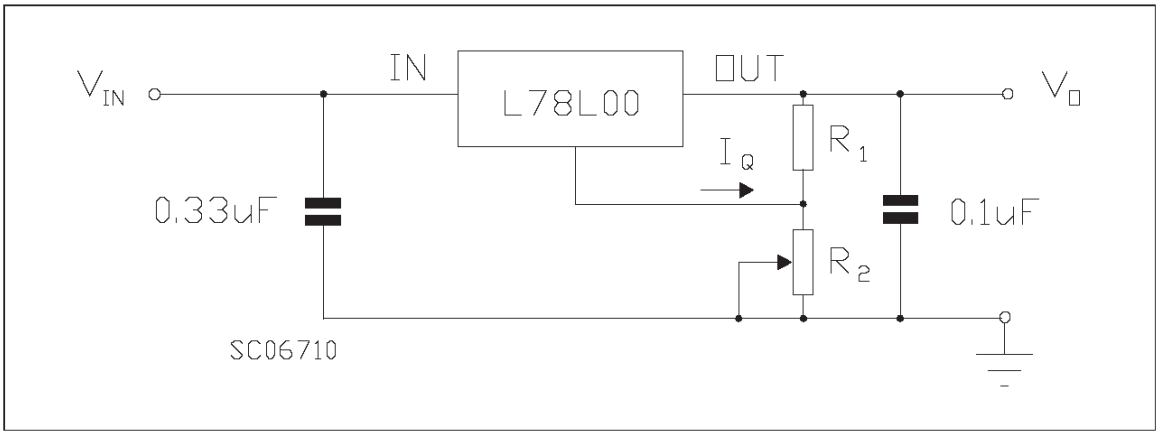
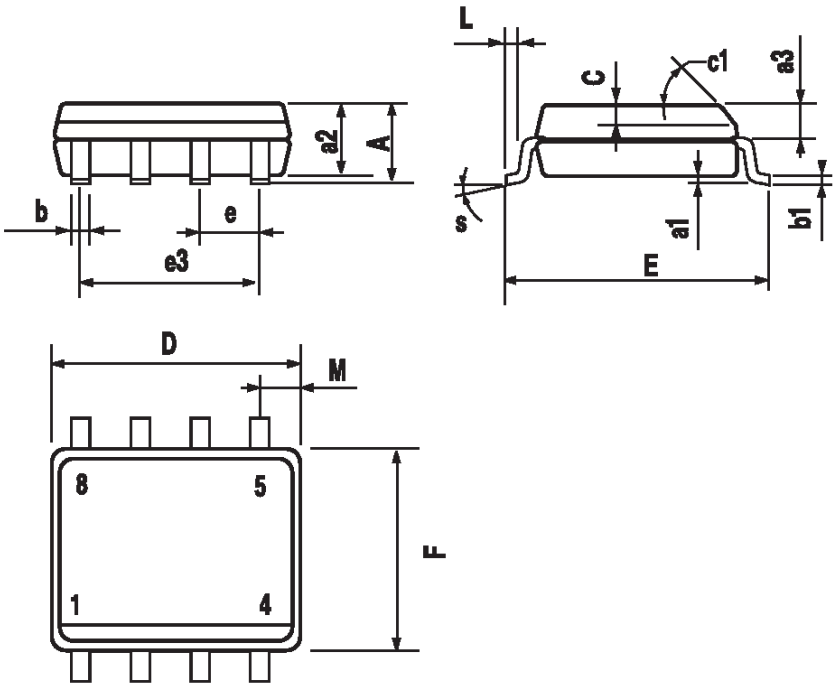


Figure 13: Adjustable Output Regulator



SO-8 MECHANICAL DATA

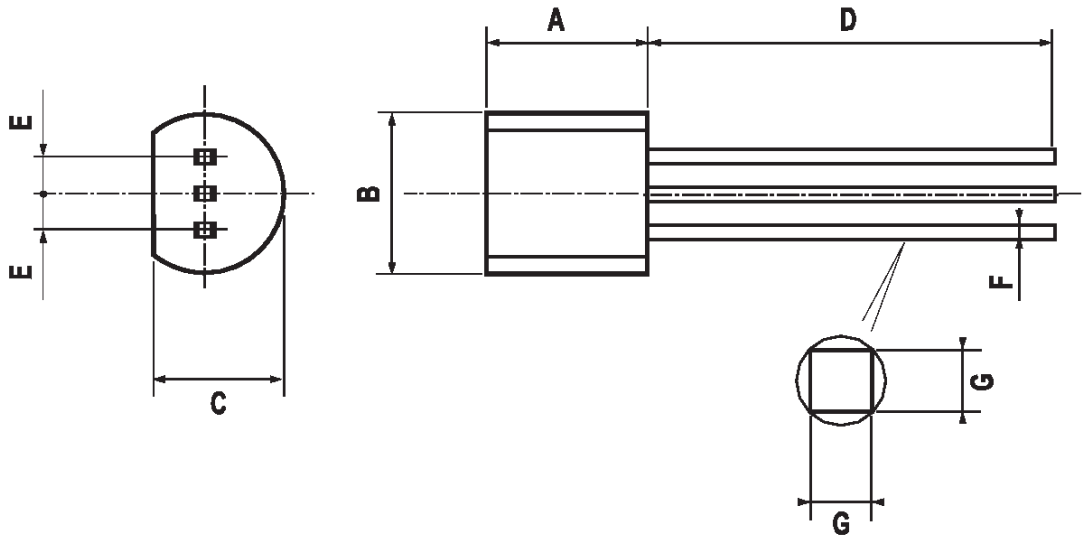
DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			1.75			0.068
a1	0.1		0.25	0.003		0.009
a2			1.65			0.064
a3	0.65		0.85	0.025		0.033
b	0.35		0.48	0.013		0.018
b1	0.19		0.25	0.007		0.010
C	0.25		0.5	0.010		0.019
c1	45 (typ.)					
D	4.8		5.0	0.188		0.196
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		3.81			0.150	
F	3.8		4.0	0.14		0.157
L	0.4		1.27	0.015		0.050
M			0.6			0.023
S	8 (max.)					



0016023

TO-92 MECHANICAL DATA

DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A	4.58		5.33	0.180		0.210
B	4.45		5.2	0.175		0.204
C	3.2		4.2	0.126		0.165
D	12.7			0.500		
E		1.27			0.050	
F	0.4		0.51	0.016		0.020
G	0.35			0.14		



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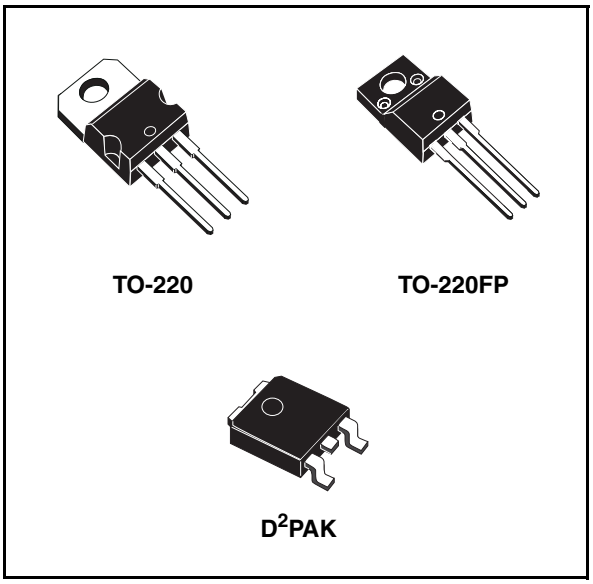
L79xxC

Negative voltage regulators

Features

- Output current up to 1.5 A
- Output voltages of -5; -8; -12; -15; -20 V
- Thermal overload protection
- Short circuit protection
- Output transition SOA protection



Description

The L79XXC series of three-terminal negative regulators is available in TO-220, TO-220FP and D^2PAK packages and several fixed output voltages, making it useful in a wide range of applications. These regulators can provide local on-card regulation, eliminating the distribution problems associated with single point regulation; furthermore, having the same voltage option as the L78XX positive standard series, they are particularly suited for split power supplies. If adequate heat sinking is provided, they can deliver over 1.5 A output current.

Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents.

Table 1. Device summary

Part numbers	Order codes			Output voltages
	TO-220 (A type)	D^2PAK	TO-220FP	
L7905C	L7905CV	L7905CD2T-TR	L7905CP	-5 V
L7908C	L7908CV			-8 V
L7912C	L7912CV	L7912CD2T-TR	L7912CP	-12 V
L7915C	L7915CV	L7915CD2T-TR	L7915CP	-15 V
L7920C	L7920CV	L7920CD2T-TR (1)		-20 V

1. Available on request.

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2 Pin configuration 4

3 Maximum ratings 5

4 Test circuit 6

5 Electrical characteristics 7

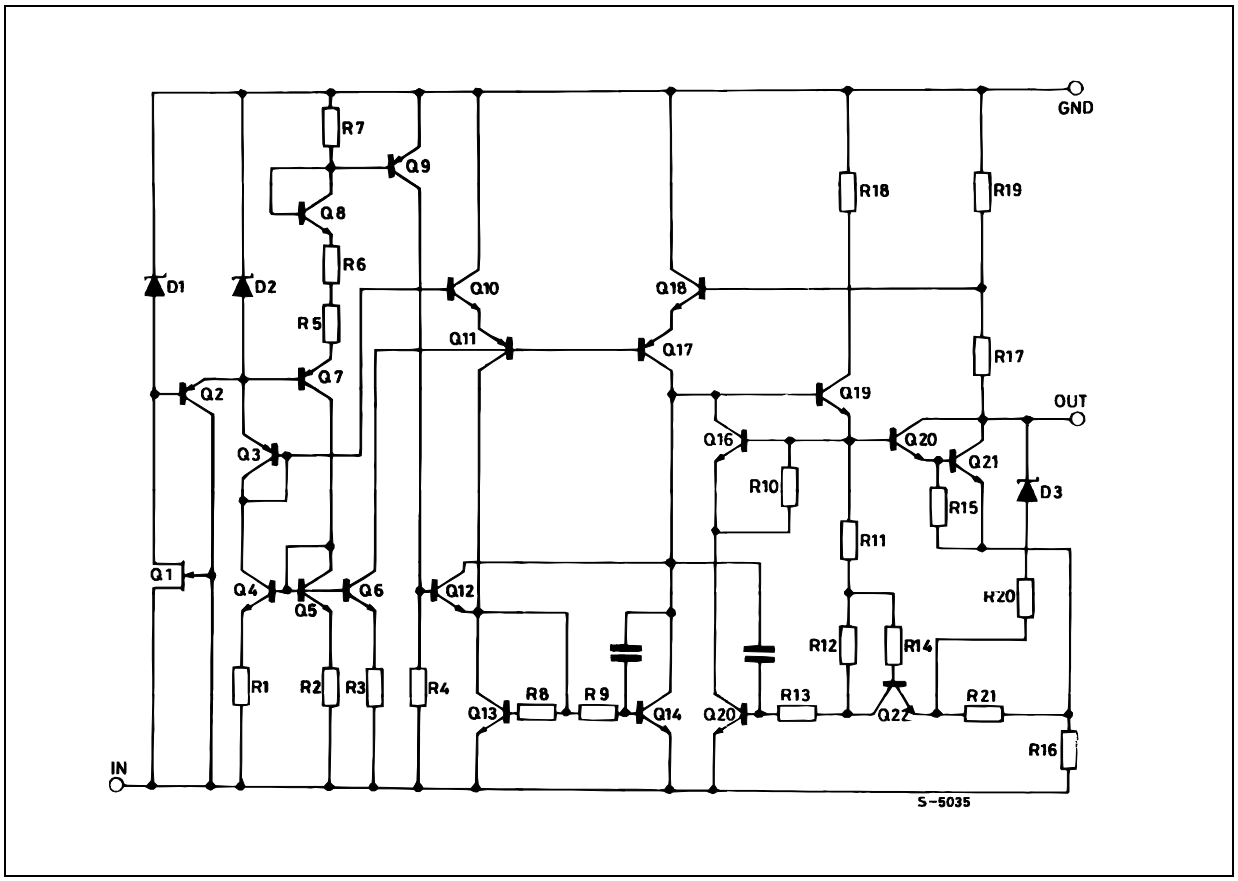
6 Application information 10

7 Package mechanical data 12

8 Revision history 20

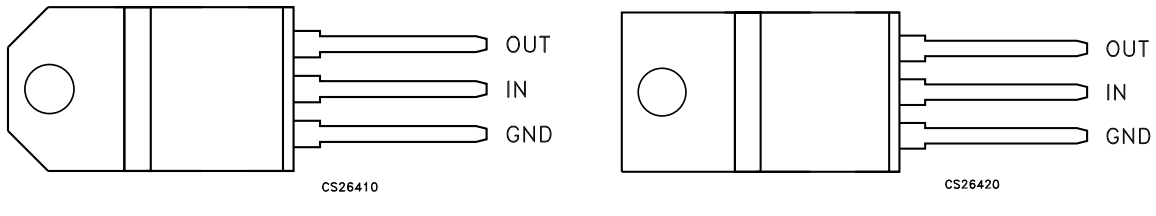
1 Diagram

Figure 1. Schematic diagram

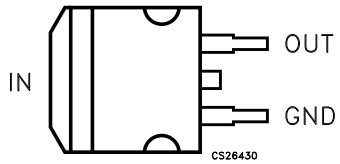


2 Pin configuration

Figure 2. Pin connections (top view)



TO-220 **TO220FP**



D²PAK (any type)

3 Maximum ratings

Table 2. Absolute maximum ratings

Symbol	Parameter		Value	Unit
V_I	DC input voltage	for V_O= 5 to 18V	-35	V
		for V_O= 20, 24V	-40	
I_O	Output current		Internally limited	
P_D	Power dissipation		Internally limited	
T_{STG}	Storage temperature range		-65 to 150	°C
T_{OP}	Operating junction temperature range		0 to 150	°C

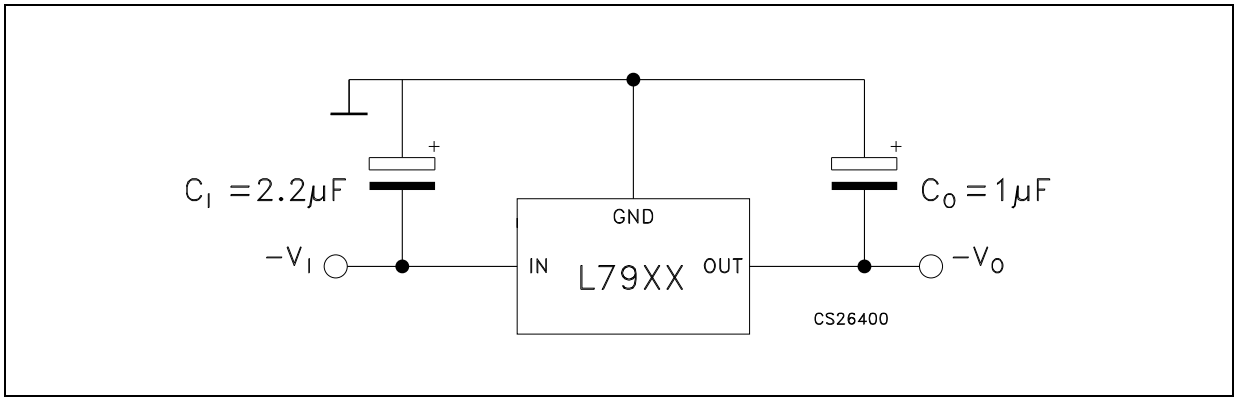
Note: Absolute maximum ratings are those values beyond which damage to the device may occur. Functional operation under these condition is not implied

Table 3. Thermal data

Symbol	Parameter	D^2PAK	TO-220	TO-220FP	Unit
R_{thJC}	Thermal resistance junction-case	3	3	5	°C/W
R_{thJA}	Thermal resistance junction-ambient	62.5	50	60	°C/W

4 Test circuit

Figure 3. Test circuit



5 Electrical characteristics

Table 4. Electrical characteristics of L7905C (refer to the test circuits, T_J = 0 to 125 °C, V_I = -10 V, I_O = 500 mA, C_I = 2.2 µF, C_O = 1 µF unless otherwise specified)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_O	Output voltage	T_J = 25°C	-4.8	-5	-5.2	V
V_O	Output voltage	I_O = -5 mA to -1 A, $P_O \leq$15 W V_I = -8 to -20 V	-4.75	-5	-5.25	V
ΔV_O(1)	Line regulation	V_I = -7 to -25 V, T_J = 25°C			100	mV
		V_I = -8 to -12 V, T_J = 25°C			50	
ΔV_O(1)	Load regulation	I_O = 5 mA to 1.5 A, T_J = 25°C			100	mV
		I_O = 250 to 750 mA, T_J = 25°C			50	
I_d	Quiescent current	T_J = 25°C			3	mA
ΔI_d	Quiescent current change	I_O = 5 mA to 1 A			0.5	mA
		V_I = -8 to -25 V			1.3	
$\Delta V_O/\Delta T$	Output voltage drift	I_O = 5 mA		-0.4		mV/°C
eN	Output noise voltage	B = 10Hz to 100kHz, T_J = 25°C		100		µV
SVR	Supply voltage rejection	ΔV_I = 10 V, f = 120Hz	54	60		dB
V_d	Dropout voltage	I_O = 1 A, T_J = 25°C, ΔV_O = 100 mV		1.4		V
I_{sc}	Short circuit current			2.1		A

1. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

Table 5. Electrical characteristics of L7908C (refer to the test circuits, T_J = 0 to 125 °C, V_I = -14 V, I_O = 500 mA, C_I = 2.2 µF, C_O = 1 µF unless otherwise specified)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_O	Output voltage	T_J = 25°C	-7.7	-8	-8.3	V
V_O	Output voltage	I_O = -5 mA to -1 A, P_O ≤15 W V_I = -11.5 to -23 V	-7.6	-8	-8.4	V
ΔV_O(1)	Line regulation	V_I = -10.5 to -25 V, T_J = 25°C			160	mV
		V_I = -11 to -17 V, T_J = 25°C			80	
ΔV_O(1)	Load regulation	I_O = 5 mA to 1.5 A, T_J = 25°C			160	mV
		I_O = 250 to 750 mA, T_J = 25°C			80	
I_d	Quiescent current	T_J = 25°C			3	mA
ΔI_d	Quiescent current change	I_O = 5 mA to 1 A			0.5	mA
		V_I = -11.5 to -25 V			1	
$\Delta V_O/\Delta T$	Output voltage drift	I_O = 5 mA		-0.6		mV/°C
eN	Output noise voltage	B = 10Hz to 100kHz, T_J = 25°C		175		µV
SVR	Supply voltage rejection	ΔV_I = 10 V, f = 120Hz	54	60		dB
V_d	Dropout voltage	I_O = 1 A, T_J = 25°C, ΔV_O = 100 mV		1.1		V
I_{sc}	Short circuit current			1.5		A

1. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

Table 6. Electrical characteristics of L7912C (refer to the test circuits, T_J = 0 to 125 °C, V_I = -19 V, I_O = 500 mA, C_I = 2.2 µF, C_O = 1 µF unless otherwise specified)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_O	Output voltage	T_J = 25°C	-11.5	-12	-12.5	V
V_O	Output voltage	I_O = -5 mA to -1 A, P_O ≤15 W V_I = -15.5 to -27 V	-11.4	-12	-12.6	V
ΔV_O(1)	Line regulation	V_I = -14.5 to -30 V, T_J = 25°C			240	mV
		V_I = -16 to -22 V, T_J = 25°C			120	
ΔV_O(1)	Load regulation	I_O = 5 mA to 1.5 A, T_J = 25°C			240	mV
		I_O = 250 to 750 mA, T_J = 25°C			120	
I_d	Quiescent current	T_J = 25°C			3	mA
ΔI_d	Quiescent current change	I_O = 5 mA to 1 A			0.5	mA
		V_I = -15 to -30 V			1	
$\Delta V_O/\Delta T$	Output voltage drift	I_O = 5 mA		-0.8		mV/°C
eN	Output noise voltage	B = 10Hz to 100kHz, T_J = 25°C		200		µV
SVR	Supply voltage rejection	ΔV_I = 10 V, f = 120Hz	54	60		dB
V_d	Dropout voltage	I_O = 1 A, T_J = 25°C, ΔV_O = 100 mV		1.1		V
I_{sc}	Short circuit current			1.5		A

1. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

Table 7. Electrical characteristics of L7915C (refer to the test circuits, T_J = 0 to 125 °C, V_I = -23 V, I_O = 500 mA, C_I = 2.2 µF, C_O = 1 µF unless otherwise specified)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_O	Output voltage	T_J = 25°C	-14.4	-15	-15.6	V
V_O	Output voltage	I_O = -5 mA to -1 A, P_O ≤15 W V_I = -18.5 to -30 V	-14.3	-15	-15.7	V
ΔV_O(1)	Line regulation	V_I = -17.5 to -30 V, T_J = 25°C			300	mV
		V_I = -20 to -26 V, T_J = 25°C			150	
ΔV_O(1)	Load regulation	I_O = 5 mA to 1.5 A, T_J = 25°C			300	mV
		I_O = 250 to 750 mA, T_J = 25°C			150	
I_d	Quiescent current	T_J = 25°C			3	mA
ΔI_d	Quiescent current change	I_O = 5 mA to 1 A			0.5	mA
		V_I = -18.5 to -30 V			1	
$\Delta V_O/\Delta T$	Output voltage drift	I_O = 5 mA		-0.9		mV/°C
eN	Output noise voltage	B = 10Hz to 100kHz, T_J = 25°C		250		µV
SVR	Supply voltage rejection	ΔV_I = 10 V, f = 120Hz	54	60		dB
V_d	Dropout voltage	I_O = 1 A, T_J = 25°C, ΔV_O = 100 mV		1.1		V
I_{sc}	Short circuit current			1.3		A

1. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

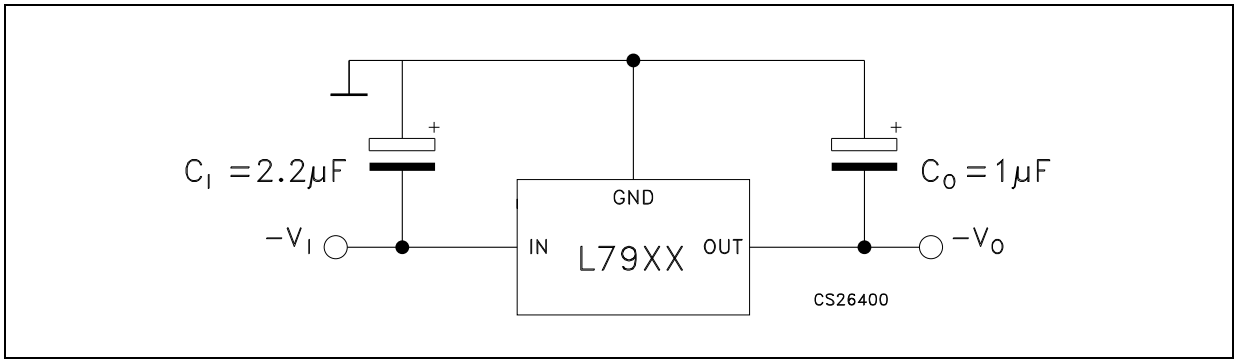
Table 8. Electrical characteristics of L7920C (refer to the test circuits, T_J = 0 to 125 °C, V_I = -29 V, I_O = 500 mA, C_I = 2.2 µF, C_O = 1 µF unless otherwise specified)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
V_O	Output voltage	T_J = 25°C	-19.2	-20	-20.8	V
V_O	Output voltage	I_O = -5 mA to -1 A, P_O ≤15 W V_I = -24 to -35 V	-19	-20	-21	V
ΔV_O(1)	Line regulation	V_I = -23 to -35 V, T_J = 25°C			400	mV
		V_I = -26 to -32 V, T_J = 25°C			200	
ΔV_O(1)	Load regulation	I_O = 5 mA to 1.5 A, T_J = 25°C			400	mV
		I_O = 250 to 750 mA, T_J = 25°C			200	
I_d	Quiescent current	T_J = 25°C			3	mA
ΔI_d	Quiescent current change	I_O = 5 mA to 1 A			0.5	mA
		V_I = -24 to -35 V			1	
$\Delta V_O/\Delta T$	Output voltage drift	I_O = 5 mA		-1.1		mV/°C
eN	Output noise voltage	B = 10Hz to 100kHz, T_J = 25°C		350		µV
SVR	Supply voltage rejection	ΔV_I = 10 V, f = 120Hz	54	60		dB
V_d	Dropout voltage	I_O = 1 A, T_J = 25°C, ΔV_O = 100 mV		1.1		V
I_{sc}	Short circuit current			0.9		A

1. Load and line regulation are specified at constant junction temperature. Changes in V_O due to heating effects must be taken into account separately. Pulse testing with low duty cycle is used.

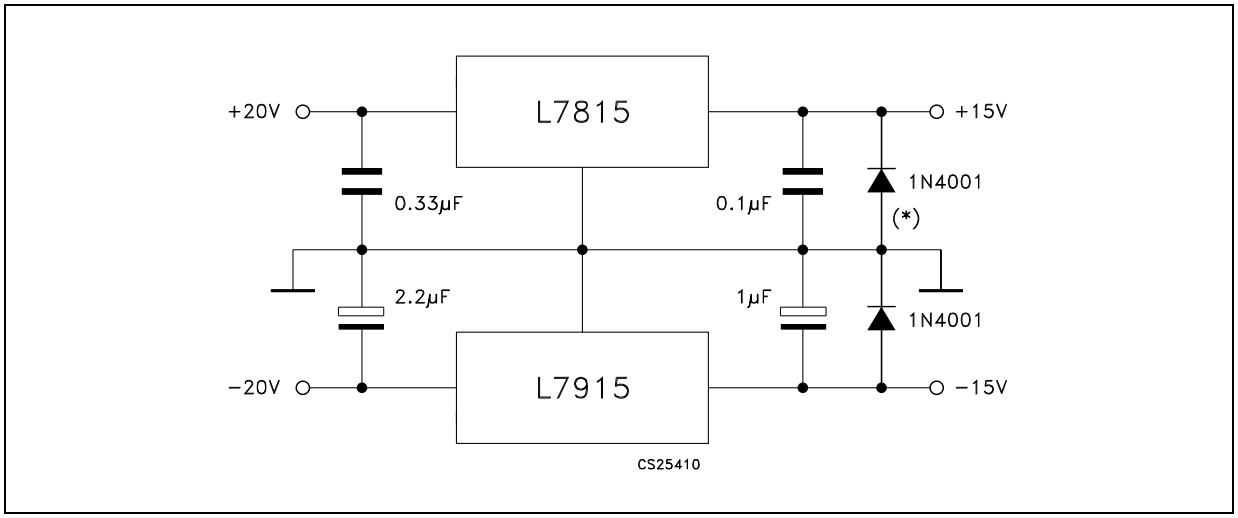
6 Application information

Figure 4. Fixed output regulator



1. To specify an output voltage, substitute voltage value for "XX".
2. Required for stability. For value given, capacitor must be solid tantalum. If aluminium electrolytic are used, at least ten times value should be selected. C1 is required if regulator is located an appreciable distance from power supply filter.
3. To improve transient response. If large capacitors are used, a high current diode from input to output (1N4001 or similar) should be introduced to protect the device from momentary input short circuit.

Figure 5. Split power supply (± 15 V - 1 A)

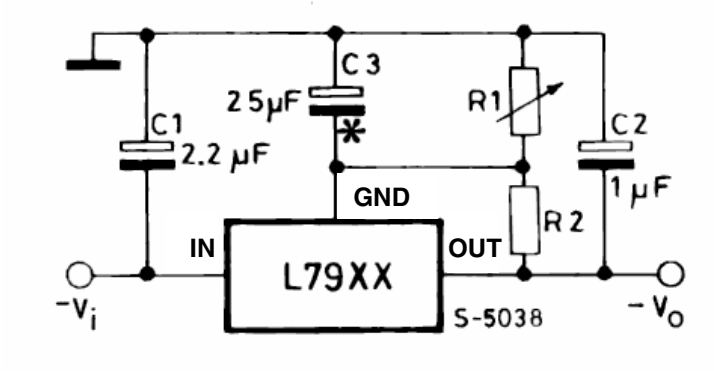


(*) Against potential latch-up problems.

Figure 6. Circuit for increasing output voltage

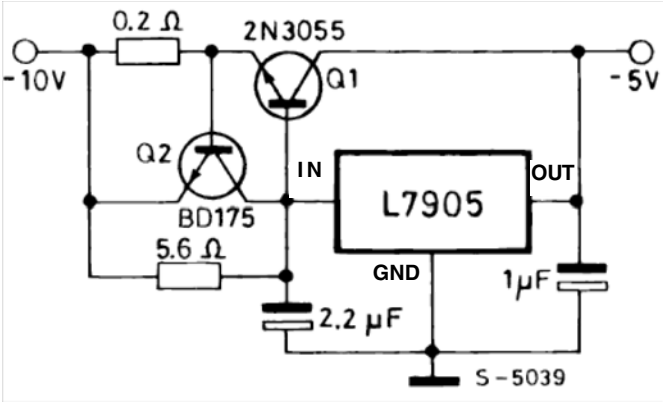
$V_O=V_{XX}(R_1+R_2)/R_2$

$V_{XX}/R_2 > 3I_d$



C3 Optional for improved transient response and ripple rejection.

Figure 7. High current negative regulator (-5 V / 4 A with 5 A current limiting)

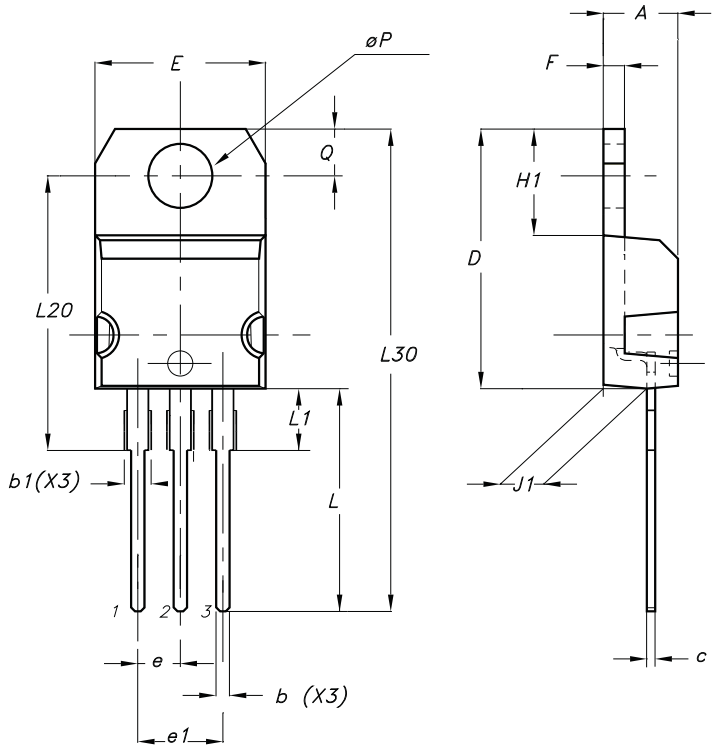


7 Package mechanical data

In order to meet environmental requirements, ST offers these devices in ECOPACK® packages. These packages have a lead-free second level interconnect. The category of second Level Interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an ST trademark. ECOPACK specifications are available at: www.st.com.

TO-220 (A type) mechanical data

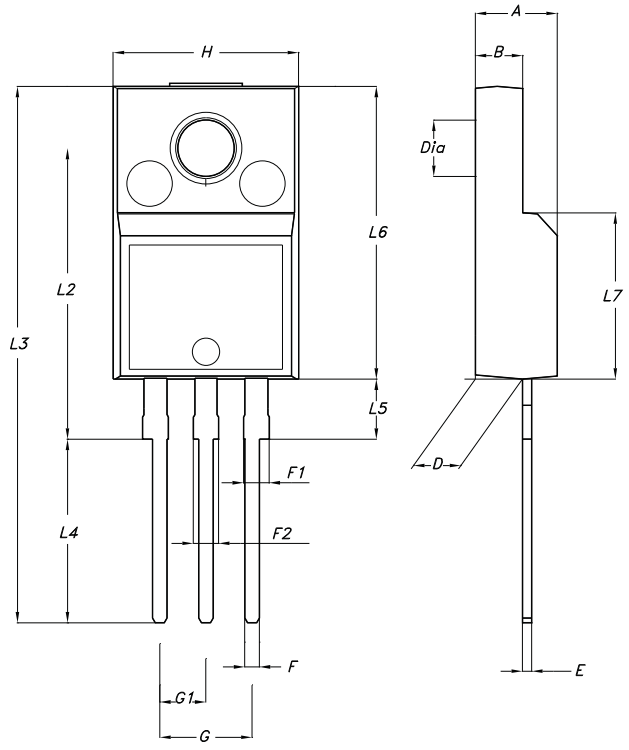
Dim.	mm.			inch.		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	4.40		4.60	0.173		0.181
b	0.61		0.88	0.024		0.035
b1	1.15		1.70	0.045		0.067
c	0.49		0.70	0.019		0.028
D	15.25		15.75	0.600		0.620
E	10.0		10.40	0.394		0.409
e	2.4		2.7	0.094		0.106
e1	4.95		5.15	0.195		0.203
F	1.23		1.32	0.048		0.052
H1	6.2		6.6	0.244		0.260
J1	2.40		2.72	0.094		0.107
L	13.0		14.0	0.512		0.551
L1	3.5		3.93	0.138		0.155
L20		16.4			0.646	
L30		28.9			1.138	
ϕP	3.75		3.85	0.148		0.152
Q	2.65		2.95	0.104		0.116



0015988/N

TO-220FP mechanical data

Dim.	mm.			inch.		
	Min.	Typ	Max.	Min.	Typ.	Max.
A	4.40		4.60	0.173		0.181
B	2.5		2.7	0.098		0.106
D	2.5		2.75	0.098		0.108
E	0.45		0.70	0.017		0.027
F	0.75		1	0.030		0.039
F1	1.15		1.50	0.045		0.059
F2	1.15		1.50	0.045		0.059
G	4.95		5.2	0.194		0.204
G1	2.4		2.7	0.094		0.106
H	10.0		10.40	0.393		0.409
L2		16			0.630	
L3	28.6		30.6	1.126		1.204
L4	9.8		10.6	0.385		0.417
L5	2.9		3.6	0.114		0.142
L6	15.9		16.4	0.626		0.645
L7	9		9.3	0.354		0.366
DIA.	3		3.2	0.118		0.126



7012510A-H

Figure 8. Drawing dimension D²PAK (type STD-ST)

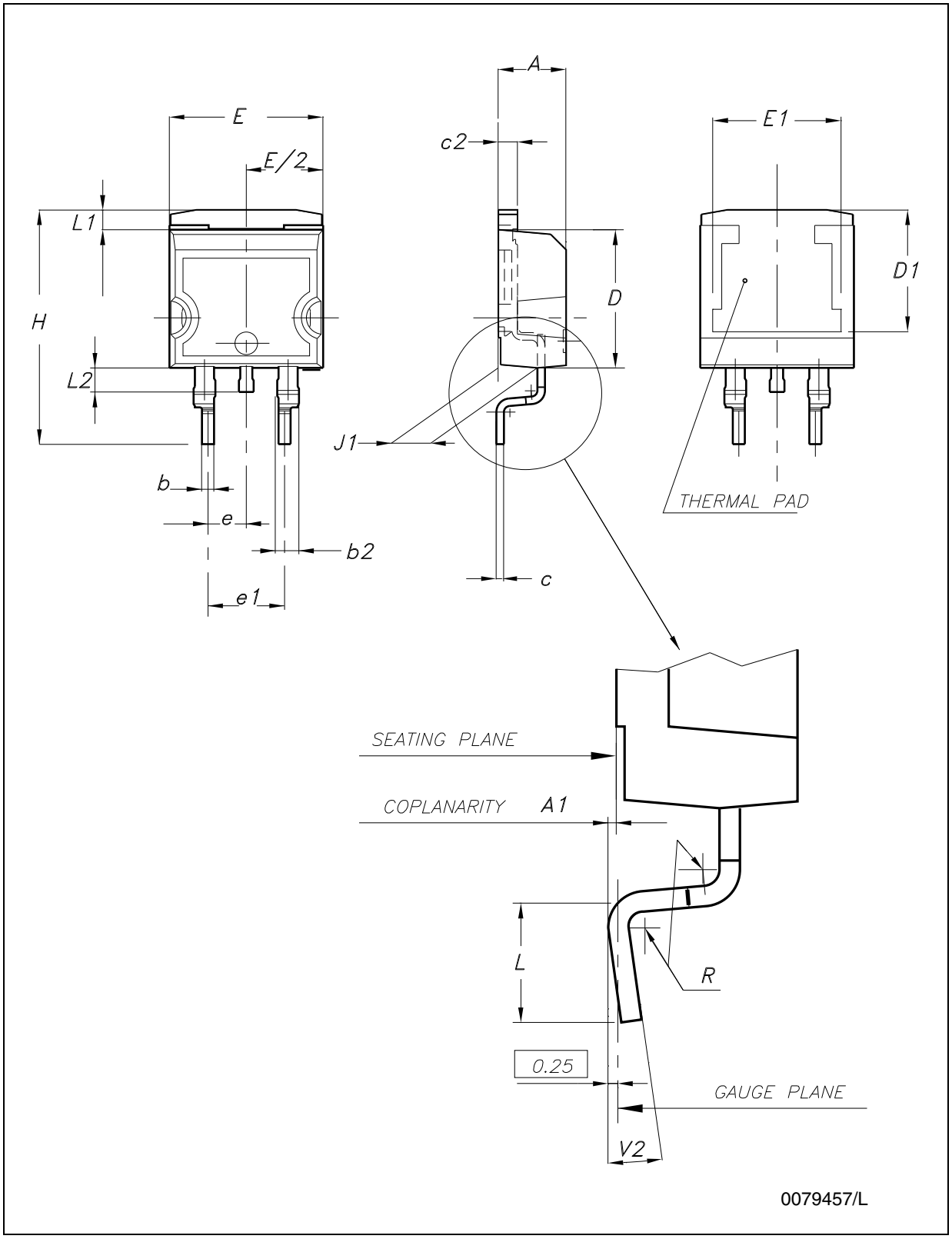


Figure 9. Drawing dimension D²PAK (type WOOSEOK-subcon.)

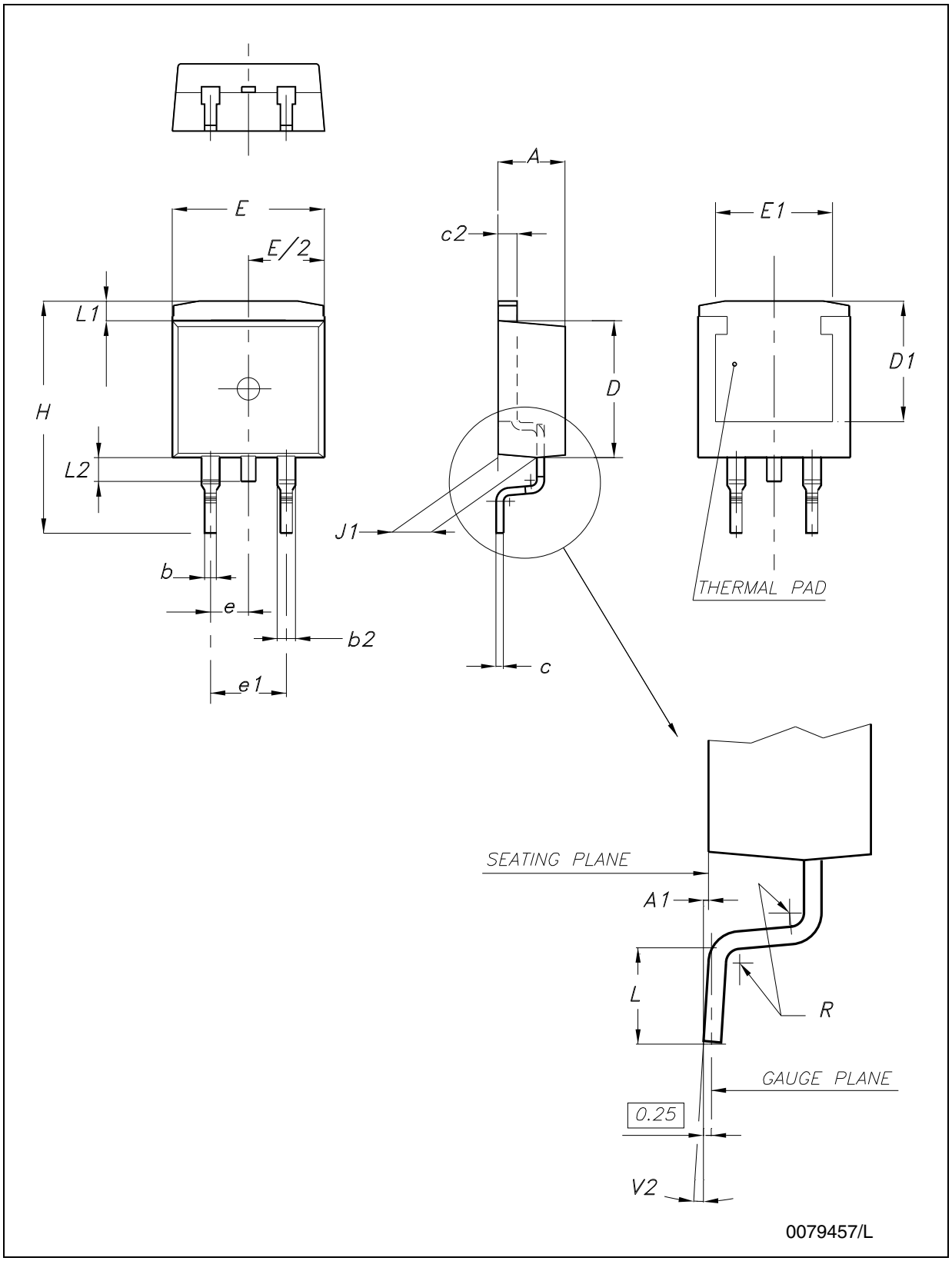


Table 9. D²PAK mechanical data

Dim.	Type STD-ST			Type WOOSEOK-subcon.		
	mm.			mm.		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A	4.40		4.60	4.30		4.70
A1	0.03		0.23	0		0.20
b	0.70		0.93	0.70		0.90
b2	1.14		1.70	1.17		1.37
c	0.45		0.60	0.45	0.50	0.60
c2	1.23		1.36	1.25	1.30	1.40
D	8.95		9.35	9	9.20	9.40
D1	7.50			7.50		
E	10		10.40	9.80		10.20
E1	8.50			7.50		
e		2.54			2.54	
e1	4.88		5.28		5.08	
H	15		15.85	15	15.30	15.60
J1	2.49		2.69	2.20		2.60
L	2.29		2.79	1.79		2.79
L1	1.27		1.40	1		1.40
L2	1.30		1.75	1.20		1.60
R		0.4			0.30	
V2	0°		8°	0°		3°

Note: The D²PAK package coming from the subcontractor WOOSEOK is fully compatible with the ST's package suggested footprint.

Figure 10. D²PAK footprint recommended data

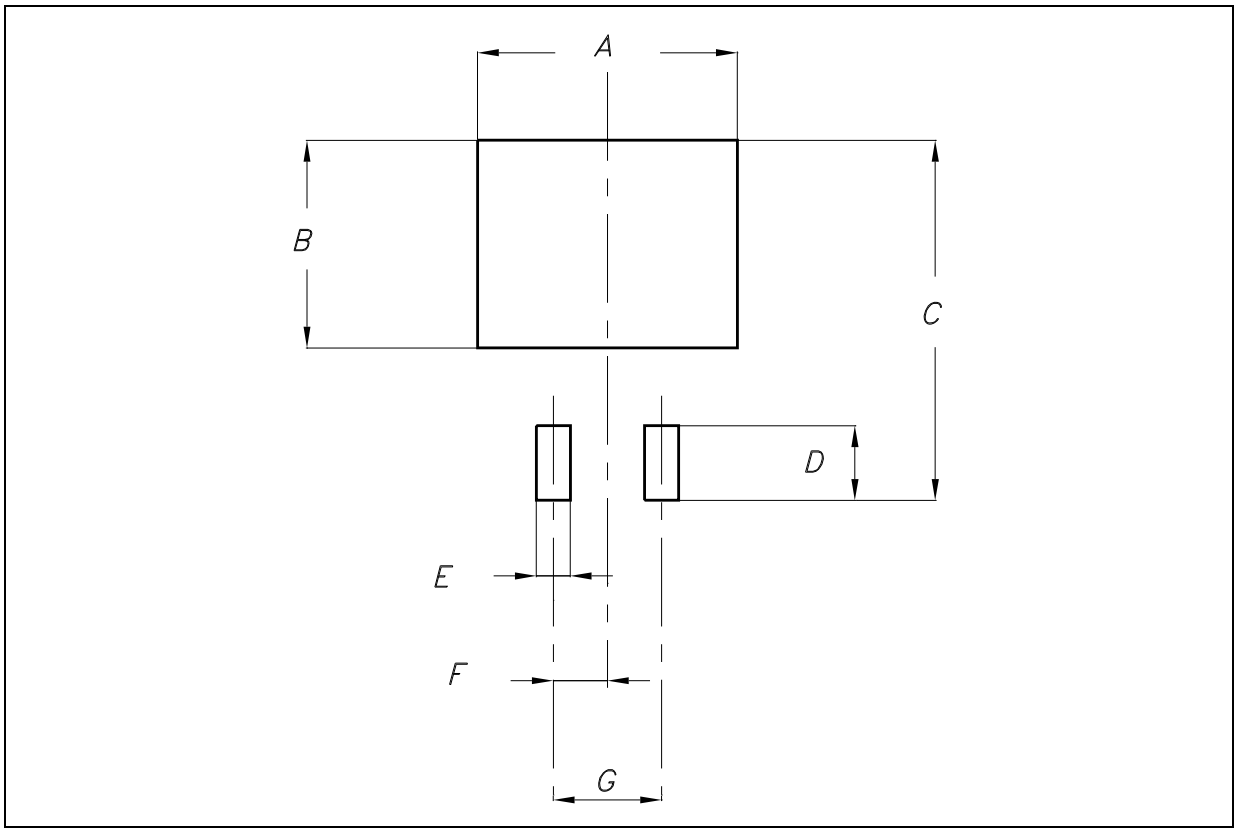
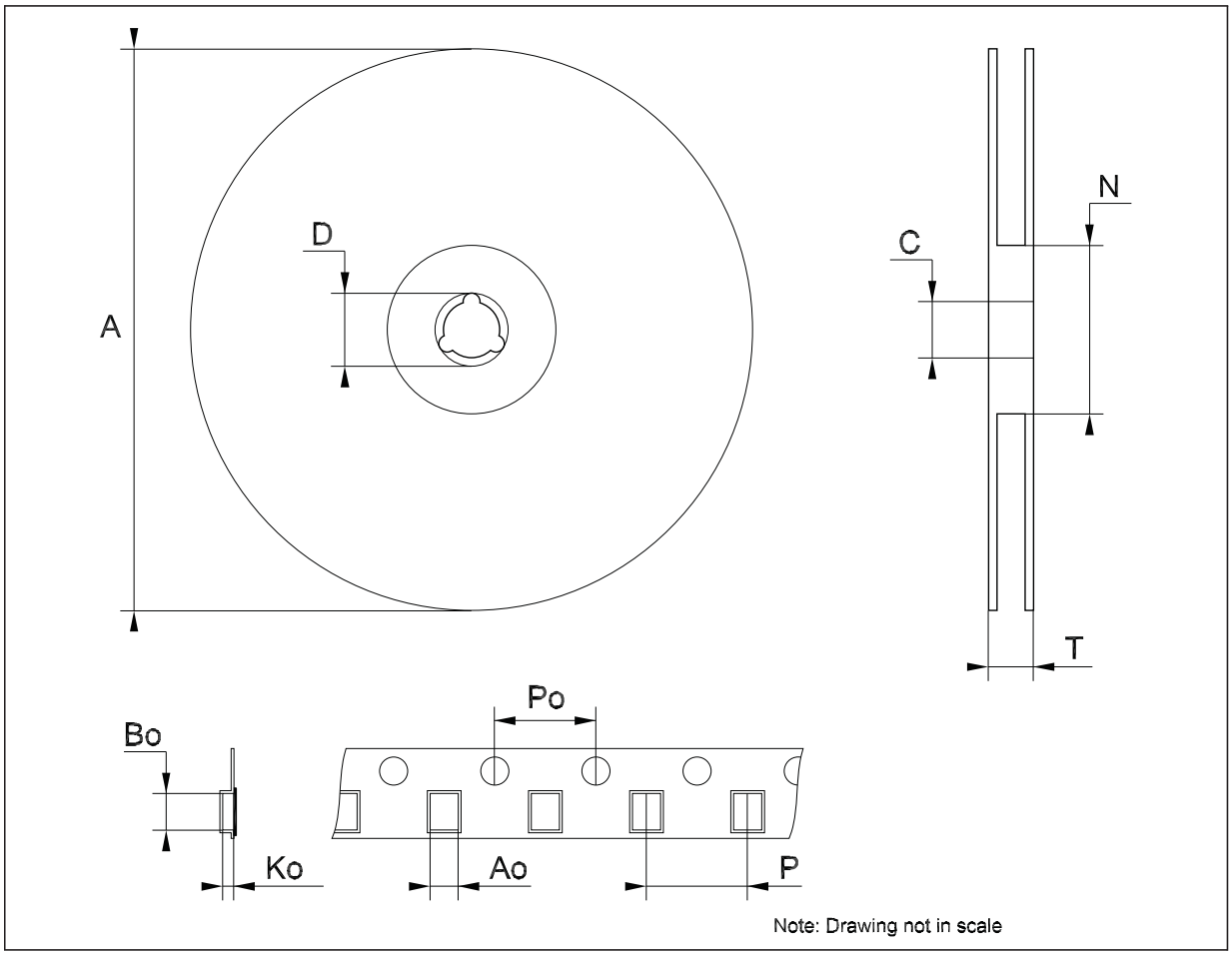


Table 10. Footprint data

Values		
Dim.	**mm.**	**inch.**
A	12.20	0.480
B	9.75	0.384
C	16.90	0.665
D	3.50	0.138
E	1.60	0.063
F	2.54	0.100
G	5.08	0.200

Tape & reel D^2PAK-P^2PAK-D^2PAK/A-P^2PAK/A mechanical data

Dim.	mm.			inch.		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			180			7.086
C	12.8	13.0	13.2	0.504	0.512	0.519
D	20.2			0.795		
N	60			2.362		
T			14.4			0.567
Ao	10.50	10.6	10.70	0.413	0.417	0.421
Bo	15.70	15.80	15.90	0.618	0.622	0.626
Ko	4.80	4.90	5.00	0.189	0.193	0.197
Po	3.9	4.0	4.1	0.153	0.157	0.161
P	11.9	12.0	12.1	0.468	0.472	0.476



Note: Drawing not in scale

8 Revision history

Table 11. Document revision history

Date	Revision	Changes
22-Jun-2004	9	Order Codes updated Table 3, pag. 3.
31-Aug-2005	10	Add new order codes (TO-220 E Type) on Table 3, pag. 3.
19-Jan-2007	11	D^2PAK mechanical data has been updated, add footprint data and the document reformatted.
06-Jun-2007	12	Order codes updated.
25-Oct-2007	13	Modified: *Figure 3*, *Figure 4*, *Figure 6* and *Figure 7*.
05-Dec-2007	14	Modified: *Table 1*.
18-Feb-2008	15	Modified: *Table 1 on page 1*.

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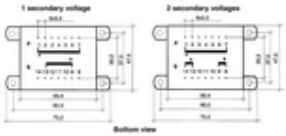
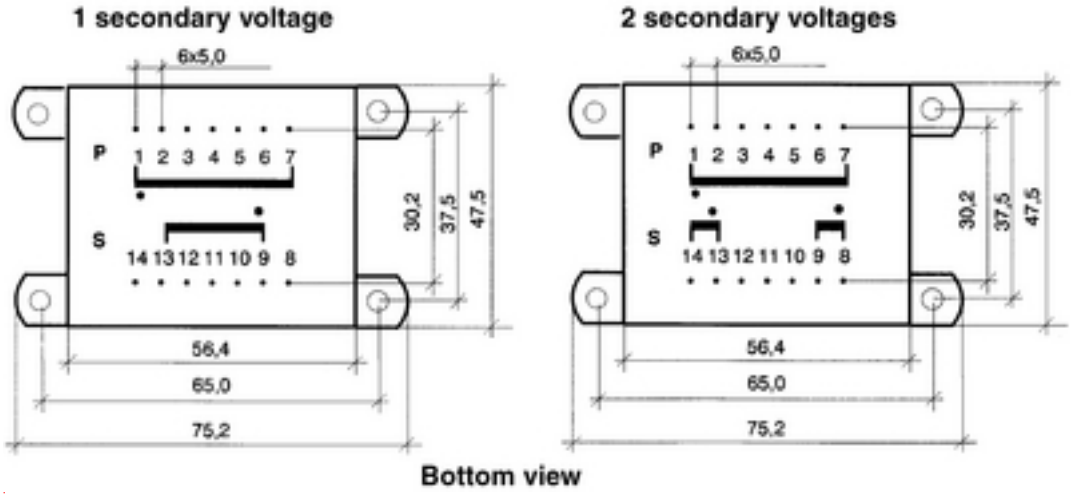
Kretskortstransformator 16 VA



Fabr Hahn
Vakuumingjuten transformator för kretskortsmontage. Med enkel eller dubbel sekundärlindning som kan serie- eller parallellkopplas. Externt överbelastningsskydd i form av säkring eller PTC-motstånd erfordras.

Primärspänning:	230 V~ ±10 % 50–60 Hz
Max primärström:	130 mA vid full last
Sekundärspänning, rms:	Se resp tabell
Avvikelse från nominell sekundärspänning:	±5 %
Temperaturklass:	T70/B
Tillverkningsnorm:	EN61558
Isolation primär-sekundär:	>4 kV
Isolation sekundär-sekundär:	500 V
Överbelastningsskydd:	Yttre säkring eller PTC-motstånd (medföljer ej)
Godkännanden:	ENEC, UL
Ingjutningsmassa:	Epoxiharts
Lödstift:	0,5×1,0×5,7 mm
Bygghöjd:	38,8 mm
Fästhål:	∅4,2 mm
Vikt:	400 g

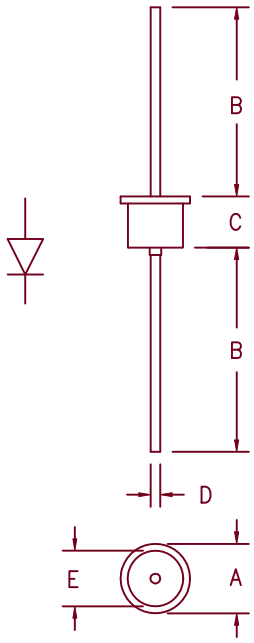


Inzomia plug-in | Visa hela bilden | Stäng fönstret

SENSOR BOARD

MedTech – MF2003
2008-05-13

5 Amp Schottky Rectifier
1N5823, 1N5824, 1N5825



Dim.	Inches		Millimeter		
	Minimum	Maximum	Minimum	Maximum	Notes
A	---	.450	---	11.43	Dia.
B	.980	---	24.89	---	
C	---	.300	---	7.62	
D	.046	.056	1.17	1.42	Dia.
E	---	.350	---	8.89	Dia.

Microsemi Catalog Number	Working Peak Reverse Voltage	Repetitive Peak Reverse Voltage
1N5823	20V	20V
1N5824	30V	30V
1N5825	40V	40V

- Schottky Barrier Rectifier
- 125°C Junction temperature
- V_{RRM} 20 to 40 Volts
- 5 Amp current rating
- Very low forward voltage
- JAN, JANTX, JANTXV & JANS equivalent screening available

Electrical Characteristics

		1N5823	1N5824	1N5825	
Average forward current	$I_{F(AV)}$	5.0A	5.0A	5.0A	T_L = 85°C, square wave, $R_{\theta JL}$ = 12°C/W
Maximum surge current	I_{FSM}	500A	500A	500A	8.3ms, half sine, T_J = 125°C
Max peak forward voltage	V_{FM}	.330V	.340V	.350V	I_{FM} = 3.0A; T_J = 25°C*
Max peak forward voltage	V_{FM}	.360V	.370V	.380V	I_{FM} = 5.0A; T_J = 25°C*
Max peak forward voltage	V_{FM}	.470V	.490V	.520V	I_{FM} = 15.7A; T_J = 25°C*
Max peak reverse current	I_{RM}	10mA	10mA	10mA	V_{RRM}, T_J = 25°C
Max peak reverse current	I_{RM}	100mA	125mA	150mA	V_{RRM}, T_J = 100°C
Typical junction capacitance	C_J	1470pF	1470pF	1470pF	V_R = 5.0V, T_J = 25°C

*Pulse test: Pulse width 300 μsec, Duty cycle 2%

Thermal and Mechanical Characteristics

Storage temperature range	T_{STG}	−65°C to 125°C
Operating junction temp range	T_J	−65°C to 125°C
Maximum thermal resistance	L = 1/4" $R_{\theta JL}$	12°C/W Junction to lead
Weight		.08 ounces (2.4 grams) typical

3-7-00 Rev. 1

COLORADO Microsemi
800 Hoyt Street
Broomfield, CO. 80020
PH: (303) 469-2161
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www.microsemi.com

1N5823, 1N5824, 1N5825

Figure 1
Typical Forward Characteristics

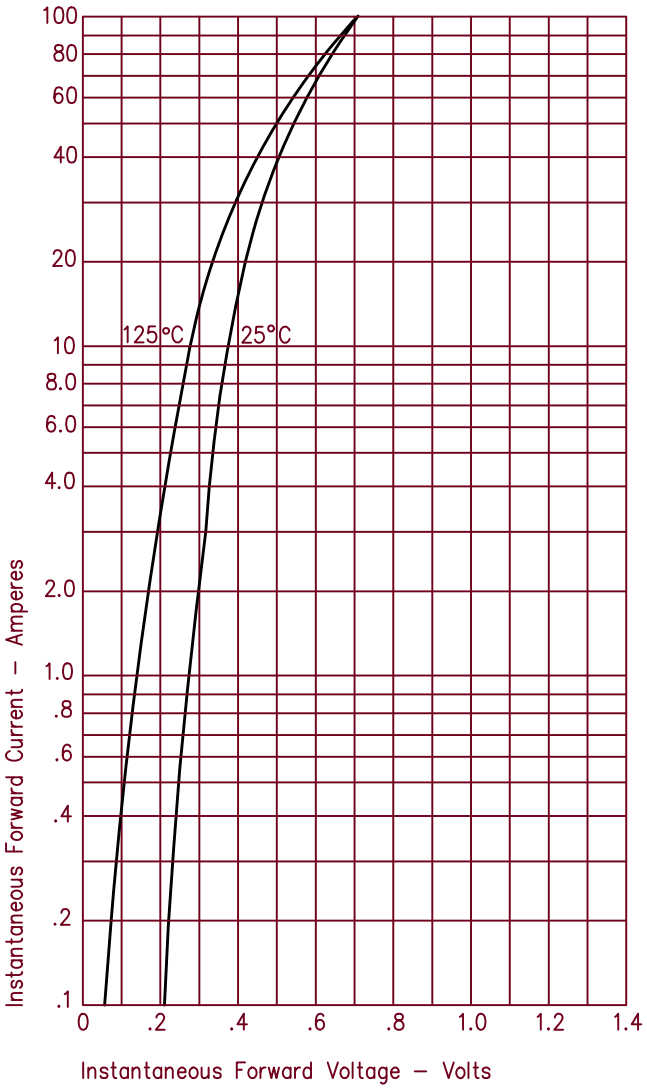


Figure 2
Typical Reverse Characteristics

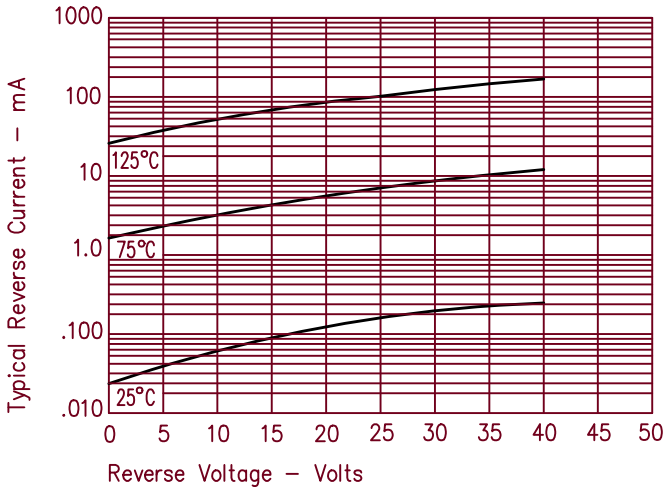
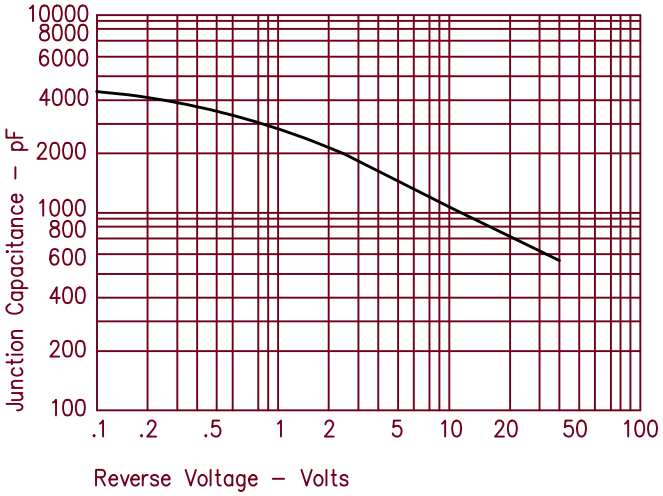


Figure 3
Typical Junction Capacitance



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Datasheets for electronics components.

2002-06-13

PRODUKTINFORMATION

Vi reserverar oss mot fel samt förbehåller oss rätten till ändringar utan föregående meddelande

ELFA artikelnr

73-386-68 INA111AP instrum op DIP8

73-386-76 INA111AU instrum op SO16W

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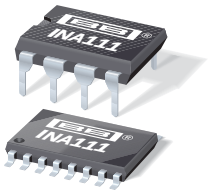


INA111

High Speed FET-Input INSTRUMENTATION AMPLIFIER

FEATURES

- FET INPUT: I_B = 20pA max
- HIGH SPEED: T_S = 4μs (G = 100, 0.01%)
- LOW OFFSET VOLTAGE: 500μV max
- LOW OFFSET VOLTAGE DRIFT: 5μV/°C max
- HIGH COMMON-MODE REJECTION: 106dB min
- 8-PIN PLASTIC DIP, SOL-16 SOIC

APPLICATIONS

- MEDICAL INSTRUMENTATION
- DATA ACQUISITION

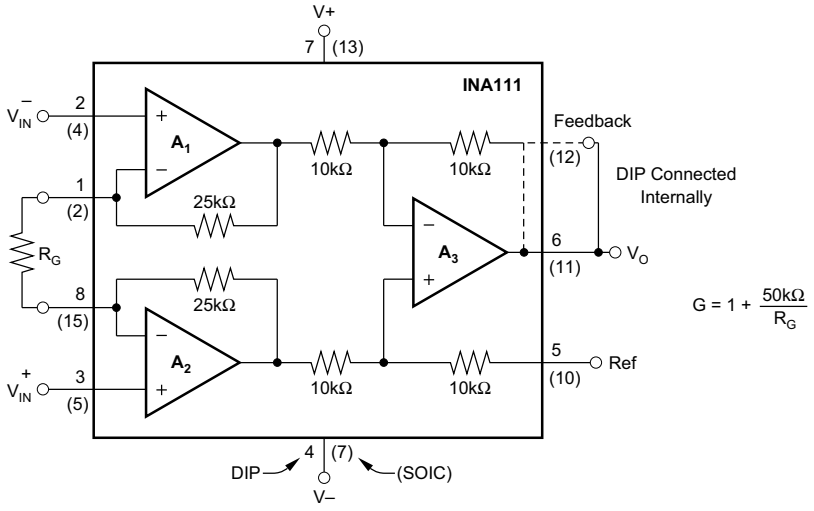
DESCRIPTION

The INA111 is a high speed, FET-input instrumentation amplifier offering excellent performance.

The INA111 uses a current-feedback topology providing extended bandwidth (2MHz at G = 10) and fast settling time (4μs to 0.01% at G = 100). A single external resistor sets any gain from 1 to over 1000.

Offset voltage and drift are laser trimmed for excellent DC accuracy. The INA111's FET inputs reduce input bias current to under 20pA, simplifying input filtering and limiting circuitry.

The INA111 is available in 8-pin plastic DIP, and SOL-16 surface-mount packages, specified for the –40°C to +85°C temperature range.



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PDS-1143E
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SBOS015

SPECIFICATIONS

ELECTRICAL

At T_A = +25°C, V_S = ±15V, R_L = 2kΩ, unless otherwise noted.

PARAMETER	CONDITIONS	INA111BP, BU			INA111AP, AU			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
INPUT								
Offset Voltage, RTI								
Initial	T_A = +25°C		±100 ± 500/G	±500 ± 2000/G		±200 ± 500/G	±1000 ± 5000/G	µV
vs Temperature	$T_A = T_{MIN}$ to T_{MAX}		±2 ± 10/G	±5 ± 100/G		±2 ± 20/G	±10 ± 100/G	µV/°C
vs Power Supply	V_S = ±6V to ±18V		2 +10/G	30 + 100/G		*	*	µV/V
Impedance, Differential			10^{12} || 6			*		Ω || pF
Common-Mode			10^{12} || 3			*		Ω || pF
Input Common-Mode Range	V_{DIFF} = 0V	±10	±12		*	*		V
Common-Mode Rejection	V_{CM} = ±10V, ΔR_S = 1kΩ							
	G = 1	80	90		75	*		dB
	G = 10	96	110		90	*		dB
	G = 100	106	115		100	*		dB
	G = 1000	106	115		100	*		dB
BIAS CURRENT			±2	±20		*	*	pA
OFFSET CURRENT			±0.1	±10		*	*	pA
NOISE VOLTAGE, RTI	G = 1000, R_S = 0Ω							
f = 100Hz			13			*		nV/√Hz
f = 1kHz			10			*		nV/√Hz
f = 10kHz			10			*		nV/√Hz
f_B = 0.1Hz to 10Hz			1			*		µVp-p
Noise Current								
f = 10kHz			0.8			*		fA/√Hz
GAIN								
Gain Equation			1 + (50kΩ/R_G)			*		V/V
Range of Gain		1		10000	*		*	V/V
Gain Error	G = 1, R_L = 10kΩ		±0.01	±0.02		*	0.05	%
	G = 10, R_L = 10kΩ		±0.1	±0.5		*	*	%
	G = 100, R_L = 10kΩ		±0.15	±0.5		*	±0.7	%
	G = 1000, R_L = 10kΩ		±0.25	±1		*	±2	%
Gain vs Temperature	G = 1		±1	±10		*	*	ppm/°C
50kΩ Resistance[1]			±25	±100		*	*	ppm/°C
Nonlinearity	G = 1		±0.0005	±0.005		*	*	% of FSR
	G = 10		±0.001	±0.005		*	±0.01	% of FSR
	G = 100		±0.001	±0.005		*	±0.01	% of FSR
	G = 1000		±0.005	±0.02		*	±0.04	% of FSR
OUTPUT								
Voltage	I_O = 5mA, T_{MIN} to T_{MAX}	±11	±12.7		*	*		V
Load Capacitance Stability			1000			*		pF
Short Circuit Current			+30/–25			*		mA
FREQUENCY RESPONSE								
Bandwidth, –3dB	G = 1		2			*		MHz
	G = 10		2			*		MHz
	G = 100		450			*		kHz
	G = 1000		50			*		kHz
Slew Rate	V_O = ±10V, G = 2 to 100		17			*		V/µs
Settling Time, 0.01%	G = 1		2			*		µs
	G = 10		2			*		µs
	G = 100		4			*		µs
	G = 1000		30			*		µs
Overload Recovery	50% Overdrive		1			*		µs
POWER SUPPLY								
Voltage Range		±6	±15	±18	*	*	*	V
Current	V_{IN} = 0V		±3.3	±4.5		*	*	mA
TEMPERATURE RANGE								
Specification		–40		85	*		*	°C
Operating		–40		125	*		*	°C
θ_{JA}			100			*		°C/W

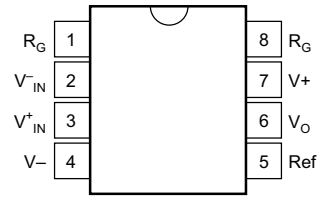
* Specification same as INA111BP.

NOTE: (1) Temperature coefficient of the "50kΩ" term in the gain equation.

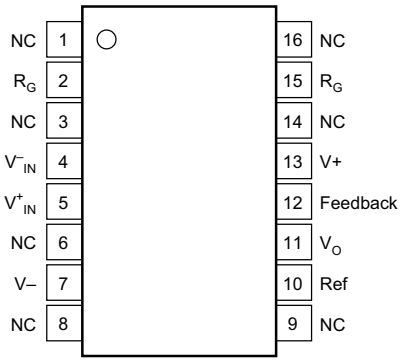
The information provided herein is believed to be reliable; however, BURR-BROWN assumes no responsibility for inaccuracies or omissions. BURR-BROWN assumes no responsibility for the use of this information, and all use of such information shall be entirely at the user's own risk. Prices and specifications are subject to change without notice. No patent rights or licenses to any of the circuits described herein are implied or granted to any third party. BURR-BROWN does not authorize or warrant any BURR-BROWN product for use in life support devices and/or systems.

PIN CONFIGURATIONS

Top View DIP



Top View SOL-16 Surface Mount



ABSOLUTE MAXIMUM RATINGS[1]

Supply Voltage	±18V
Input Voltage Range	(V–) –0.7V to (V+) +15V
Output Short-Circuit (to ground)	Continuous
Operating Temperature	–40°C to +125°C
Storage Temperature	–40°C to +125°C
Junction Temperature	+150°C
Lead Temperature (soldering, 10s)	+300°C

NOTE: Stresses above these ratings may cause permanent damage.

ELECTROSTATIC DISCHARGE SENSITIVITY

This integrated circuit can be damaged by ESD. Burr-Brown recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

ORDERING INFORMATION

PRODUCT	PACKAGE	TEMPERATURE RANGE
INA111AP	8-Pin Plastic DIP	–40°C to +85°C
INA111BP	8-Pin Plastic DIP	–40°C to +85°C
INA111AU	SOL-16 Surface-Mount	–40°C to +85°C
INA111BU	SOL-16 Surface-Mount	–40°C to +85°C

PACKAGE INFORMATION

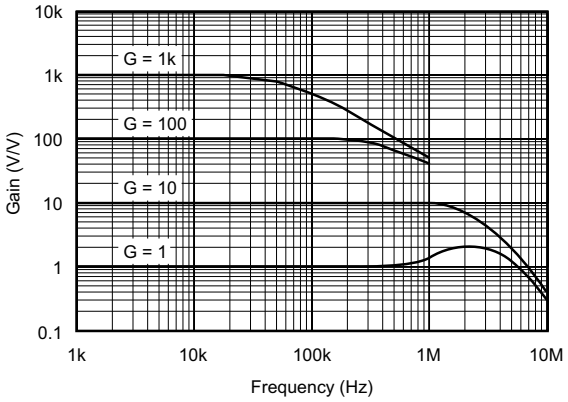
PRODUCT	PACKAGE	PACKAGE DRAWING NUMBER[1]
INA111AP	8-Pin Plastic DIP	006
INA111BP	8-Pin Plastic DIP	006
INA111AU	16-Pin Surface Mount	211
INA111BU	16-Pin Surface Mount	211

NOTE: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix C of Burr-Brown IC Data Book.

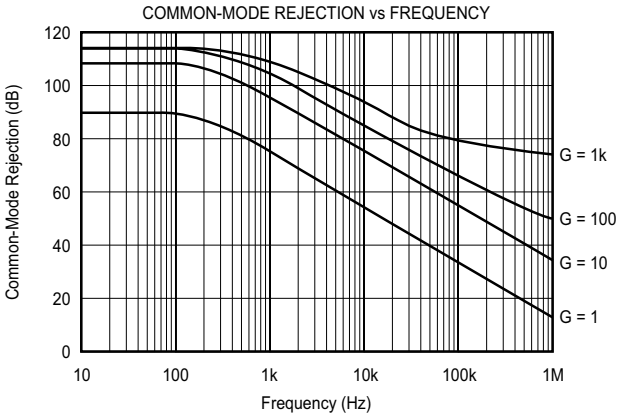
TYPICAL PERFORMANCE CURVES

At T_A = +25°C, V_S = ±15V, unless otherwise noted.

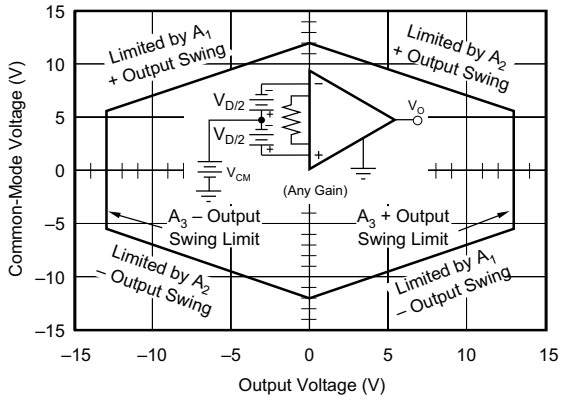
GAIN vs FREQUENCY



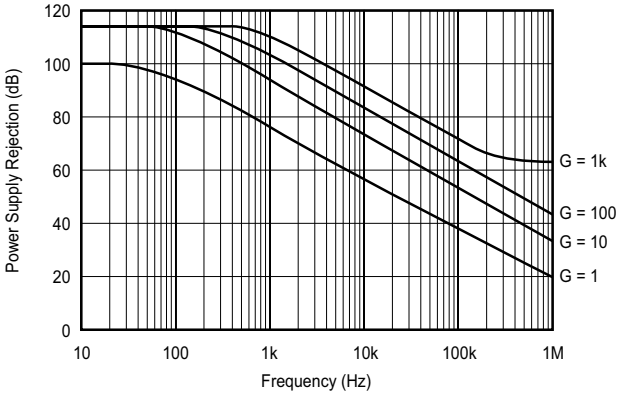
COMMON-MODE REJECTION vs FREQUENCY



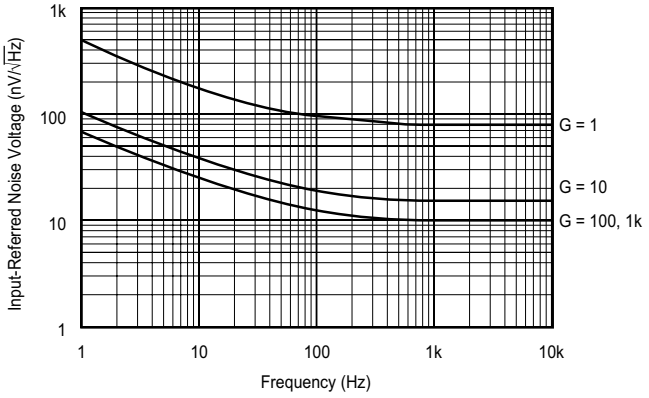
INPUT COMMON-MODE VOLTAGE RANGE vs OUTPUT VOLTAGE



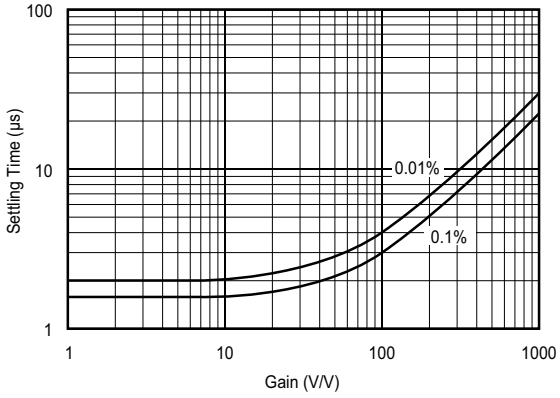
POWER SUPPLY REJECTION vs FREQUENCY



INPUT-REFERRED NOISE VOLTAGE vs FREQUENCY



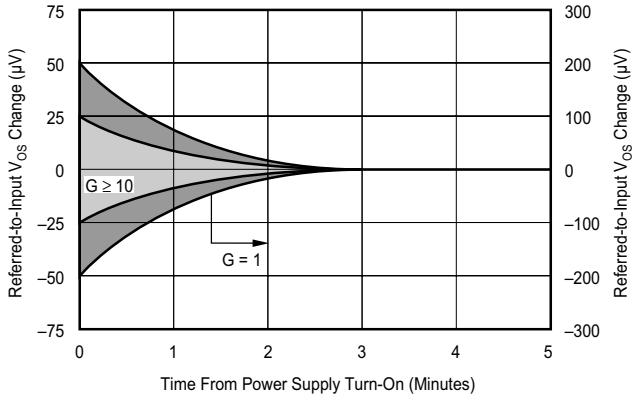
SETTLING TIME vs GAIN



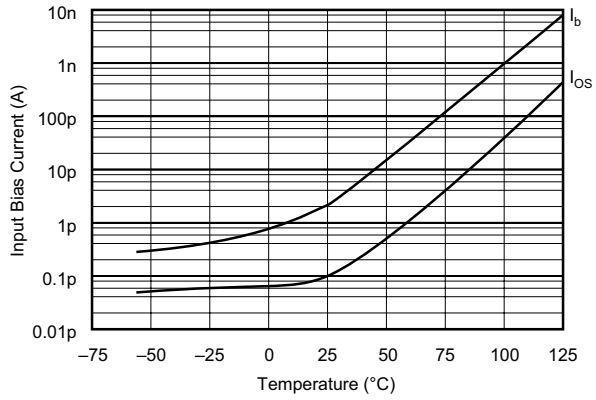
TYPICAL PERFORMANCE CURVES (CONT)

At T_A = +25°C, V_S = ±15V, unless otherwise noted.

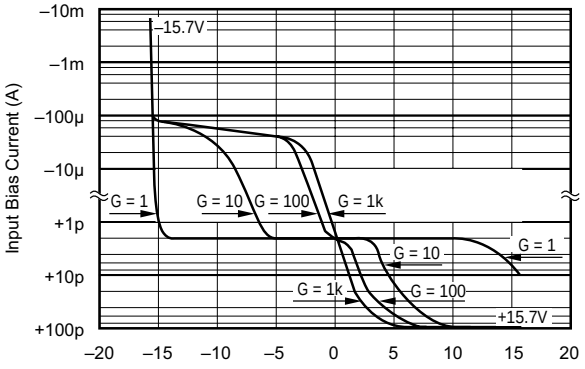
OFFSET VOLTAGE WARM-UP vs TIME



INPUT BIAS CURRENT vs TEMPERATURE

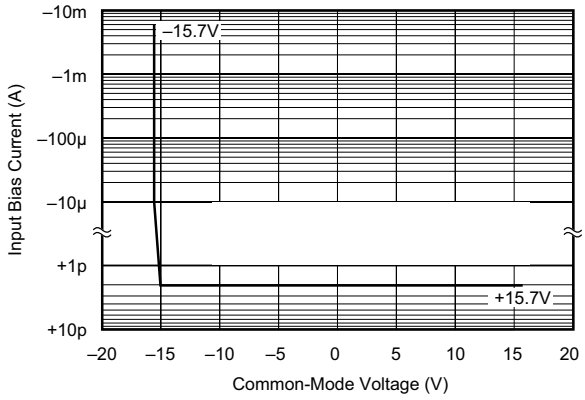


INPUT BIAS CURRENT
vs DIFFERENTIAL INPUT VOLTAGE

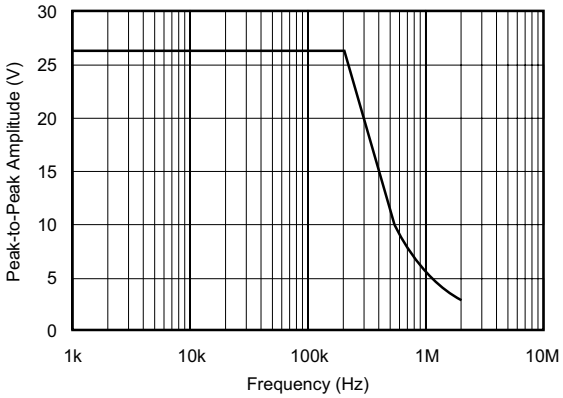


NOTE: One input grounded.

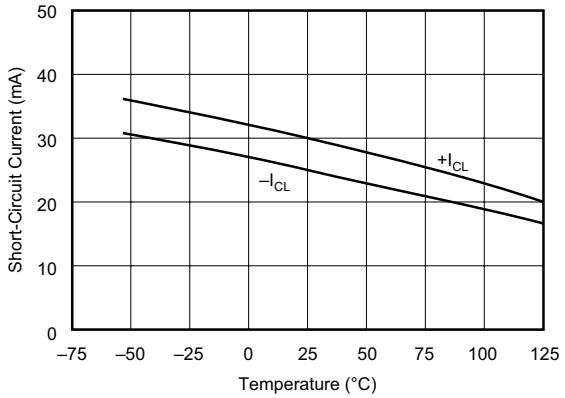
INPUT BIAS CURRENT
vs COMMON-MODE INPUT VOLTAGE



MAXIMUM OUTPUT VOLTAGE SWING vs FREQUENCY



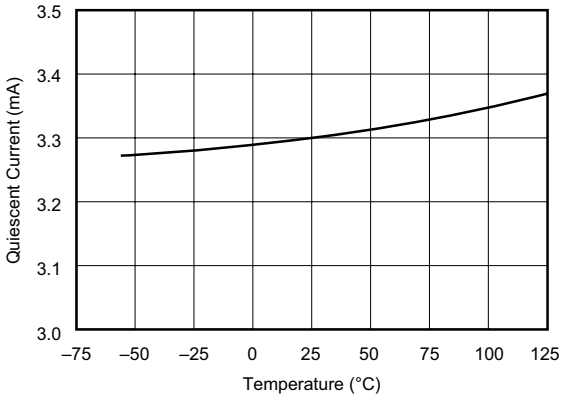
OUTPUT CURRENT LIMIT vs TEMPERATURE



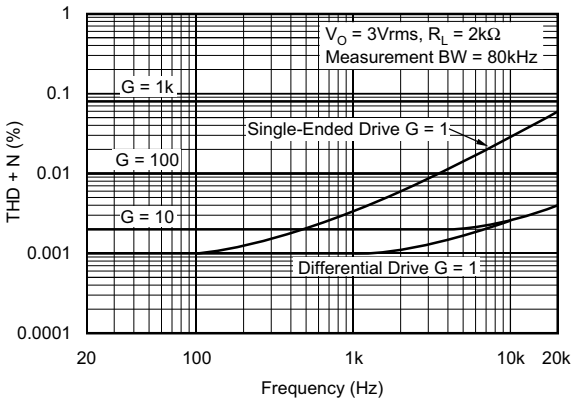
TYPICAL PERFORMANCE CURVES (CONT)

At T_A = +25°C, V_S = ±15V, unless otherwise noted.

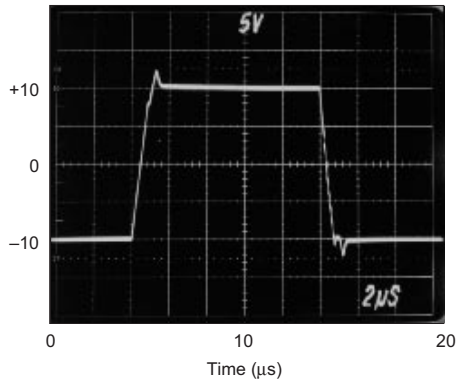
QUIESCENT CURRENT vs TEMPERATURE



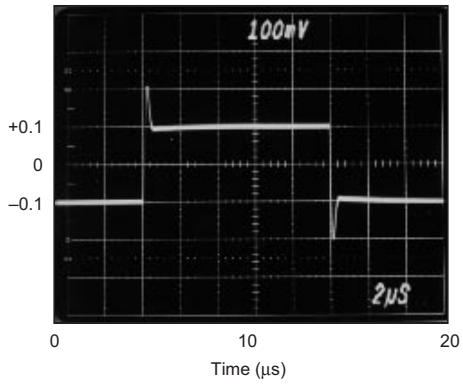
TOTAL HARMONIC DISTORTION + NOISE vs FREQUENCY



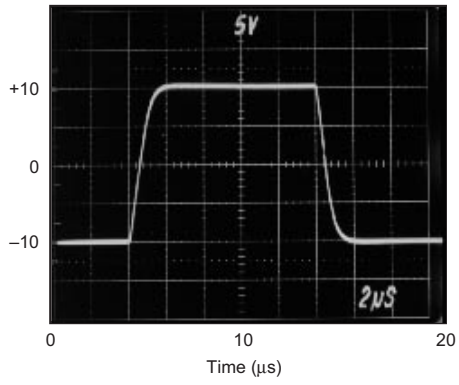
LARGE SIGNAL RESPONSE, G = 100



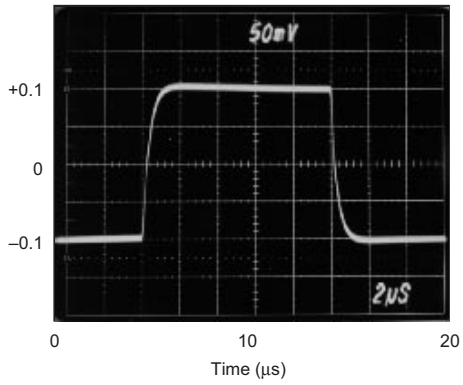
SMALL SIGNAL RESPONSE, G = 1



LARGE SIGNAL RESPONSE, G = 100



SMALL SIGNAL RESPONSE, G = 1



APPLICATION INFORMATION

Figure 1 shows the basic connections required for operation of the INA111. Applications with noisy or high impedance power supplies may require decoupling capacitors close to the device pins as shown.

The output is referred to the output reference (Ref) terminal which is normally grounded. This must be a low-impedance connection to assure good common-mode rejection. A resistance of 2Ω in series with the Ref pin will cause a typical device with 90dB CMR to degrade to approximately 80dB CMR (G = 1).

SETTING THE GAIN

Gain of the INA111 is set by connecting a single external resistor, R_G:

$$G = 1 + \frac{50k\Omega}{R_G} \quad (1)$$

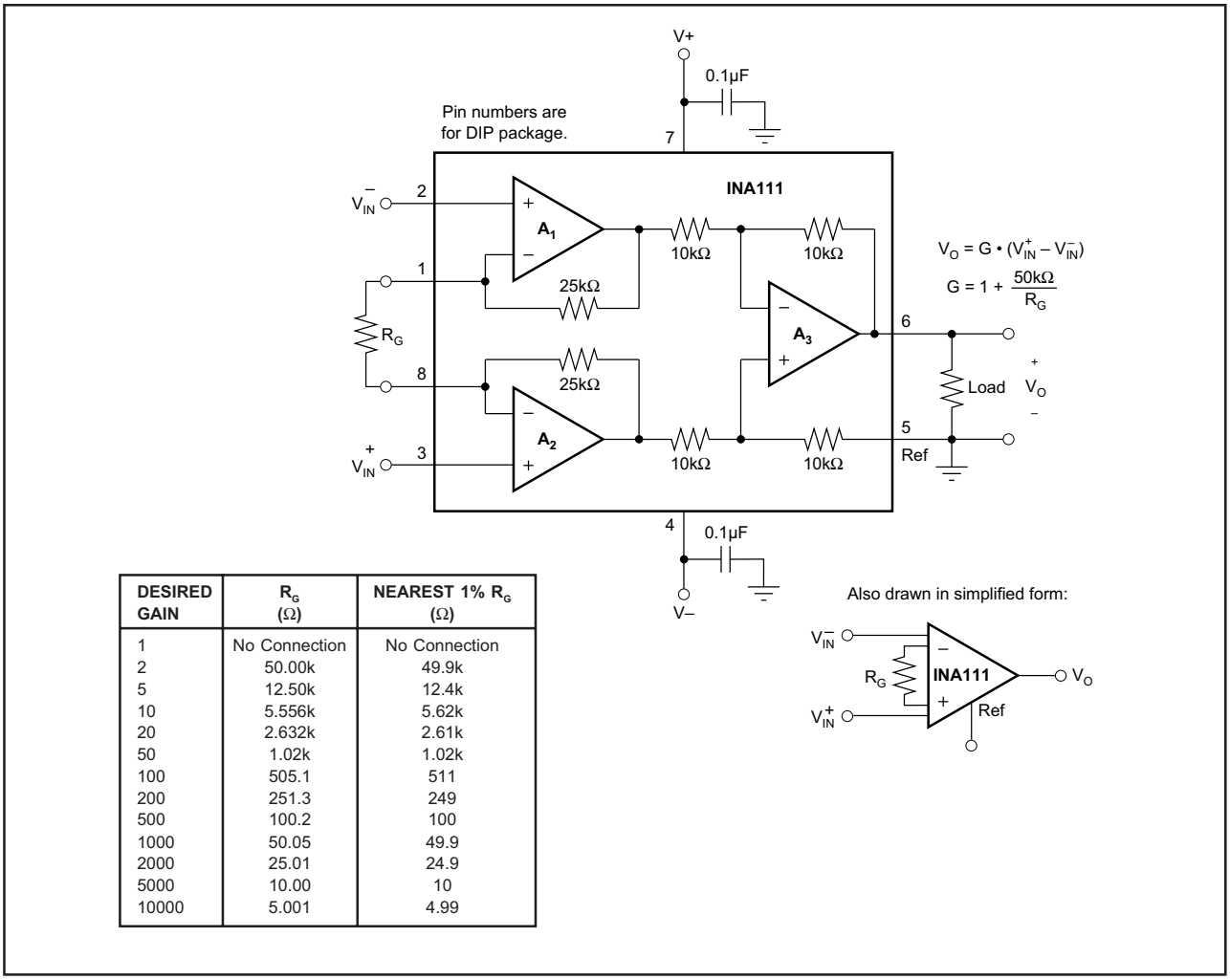
Commonly used gains and resistor values are shown in Figure 1.

The 50kΩ term in equation 1 comes from the sum of the two internal feedback resistors. These are on-chip metal film resistors which are laser trimmed to accurate absolute values. The accuracy and temperature coefficient of these resistors are included in the gain accuracy and drift specifications of the INA111.

The stability and temperature drift of the external gain setting resistor, R_G, also affects gain. R_G's contribution to gain accuracy and drift can be directly inferred from the gain equation (1). Low resistor values required for high gain can make wiring resistance important. Sockets add to the wiring resistance, which will contribute additional gain error (possibly an unstable gain error) in gains of approximately 100 or greater.

DYNAMIC PERFORMANCE

The typical performance curve "Gain vs Frequency" shows that the INA111 achieves wide bandwidth over a wide range of gain. This is due to the current-feedback topology of the INA111. Settling time also remains excellent over wide gains.



DESIRED GAIN	R_G (Ω)	NEAREST 1% R_G (Ω)
1	No Connection	No Connection
2	50.00k	49.9k
5	12.50k	12.4k
10	5.556k	5.62k
20	2.632k	2.61k
50	1.02k	1.02k
100	505.1	511
200	251.3	249
500	100.2	100
1000	50.05	49.9
2000	25.01	24.9
5000	10.00	10
10000	5.001	4.99

FIGURE 1. Basic Connections

The INA111 exhibits approximately 6dB rise in gain at 2MHz in unity gain. This is a result of its current-feedback topology and is not an indication of instability. Unlike an op amp with poor phase margin, the rise in response is a predictable +6dB/octave due to a response zero. A simple pole at 700kHz or lower will produce a flat passband response (see Input Filtering).

The INA111 provides excellent rejection of high frequency common-mode signals. The typical performance curve, "Common-Mode Rejection vs Frequency" shows this behavior. If the inputs are not properly balanced, however, common-mode signals can be converted to differential signals. Run the V_{IN}^+ and V_{IN}^- connections directly adjacent each other, from the source signal all the way to the input pins. If possible use a ground plane under both input traces. Avoid running other potentially noisy lines near the inputs.

NOISE AND ACCURACY PERFORMANCE

The INA111's FET input circuitry provides low input bias current and high speed. It achieves lower noise and higher accuracy with high impedance sources. With source impedances of 2kΩ to 50kΩ the INA114 may provide lower offset voltage and drift. For very low source impedance (≤1kΩ), the INA103 may provide improved accuracy and lower noise.

OFFSET TRIMMING

The INA111 is laser trimmed for low offset voltage and drift. Most applications require no external offset adjustment. Figure 2 shows an optional circuit for trimming the output offset voltage. The voltage applied to Ref terminal is summed at the output. Low impedance must be maintained at this node to assure good common-mode rejection. The op amp shown maintains low output impedance at high frequency. Trim circuits with higher source impedance should be buffered with an op amp follower circuit to assure low impedance on the Ref pin.

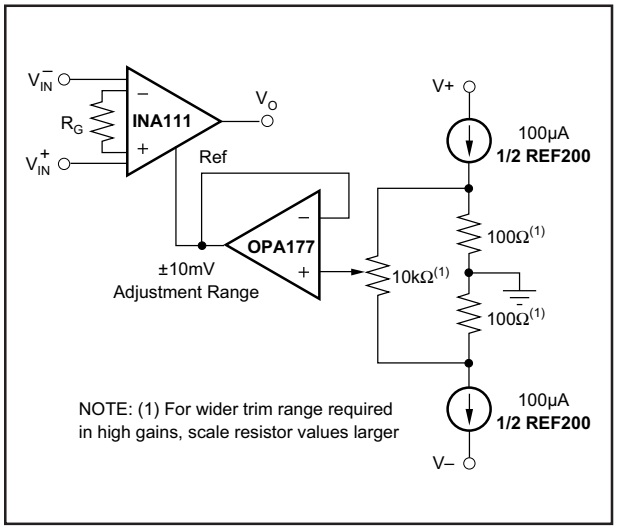


FIGURE 2. Optional Trimming of Output Offset Voltage.

INPUT BIAS CURRENT RETURN PATH

The input impedance of the INA111 is extremely high—approximately $10^{12}\Omega$. However, a path must be provided for the input bias current of both inputs. This input bias current is typically less than 10pA. High input impedance means that this input bias current changes very little with varying input voltage.

Input circuitry must provide a path for this input bias current if the INA111 is to operate properly. Figure 3 shows various provisions for an input bias current path. Without a bias current return path, the inputs will float to a potential which exceeds the common-mode range of the INA111 and the input amplifiers will saturate.

If the differential source resistance is low, the bias current return path can be connected to one input (see the thermocouple example in Figure 3). With higher source impedance, using two resistors provides a balanced input with possible advantages of lower input offset voltage due to bias current and better high-frequency common-mode rejection.

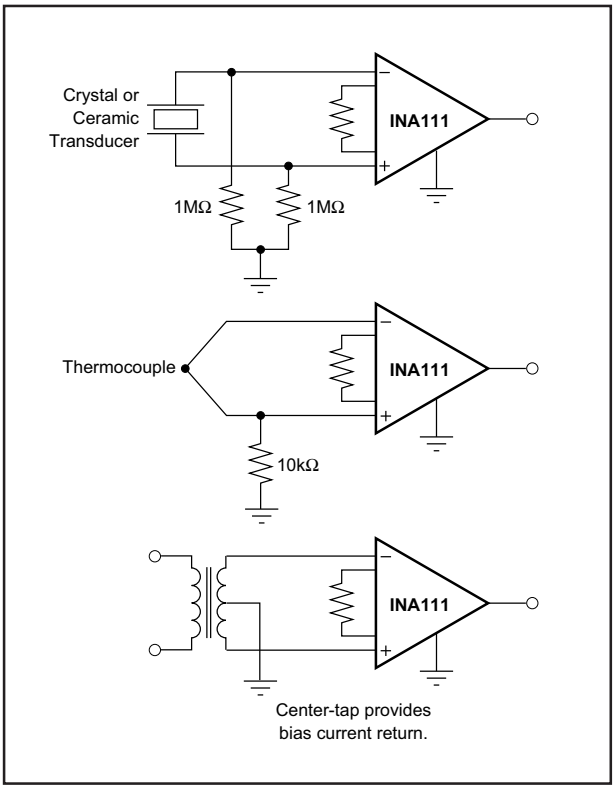


FIGURE 3. Providing an Input Common-Mode Current Path.

INPUT COMMON-MODE RANGE

The linear common-mode range of the input op amps of the INA111 is approximately ±12V (or 3V from the power supplies). As the output voltage increases, however, the linear input range will be limited by the output voltage swing of the input amplifiers, A_1 and A_2. The common-mode range is related to the output voltage of the complete amplifier—see performance curve "Input Common-Mode Range vs Output Voltage".

A combination of common-mode and differential input voltage can cause the output of A_1 or A_2 to saturate. Figure 4 shows the output voltage swing of A_1 and A_2 expressed in terms of a common-mode and differential input voltages. For applications where input common-mode range must be maximized, limit the output voltage swing by connecting the INA111 in a lower gain (see performance curve "Input Common-Mode Voltage Range vs Output Voltage"). If necessary, add gain after the INA111 to increase the voltage swing.

Input-overload often produces an output voltage that appears normal. For example, consider an input voltage of +14V on one input and +15V on the other input will obviously exceed the linear common-mode range of both input amplifiers. Since both input amplifiers are saturated to the nearly the same output voltage limit, the difference voltage measured by the output amplifier will be near zero. The output of the INA111 will be near 0V even though both inputs are overloaded.

INPUT PROTECTION

Inputs of the INA111 are protected for input voltages from 0.7V below the negative supply to 15V above the positive power supply voltages. If the input current is limited to less than 1mA, clamp diodes are not required; internal junctions will clamp the input voltage to safe levels. If the input source can supply more than 1mA, use external clamp diodes as shown in Figure 5. The source current can be limited with series resistors R_1 and R_2 as shown. Resistor values greater than 10kΩ will contribute noise to the circuit.

A diode formed with a 2N4117A transistor as shown in Figure 5 assures low leakage. Common signal diodes such as the 1N4148 may have leakage currents far greater than the input bias current of the INA111 and are usually sensitive to light.

INPUT FILTERING

The INA111's FET input allows use of an R/C input filter without creating large offsets due to input bias current. Figure 6 shows proper implementation of this input filter to preserve the INA111's excellent high frequency common-mode rejection. Mismatch of the common-mode input capacitance (C_1 and C_2), either from stray capacitance or

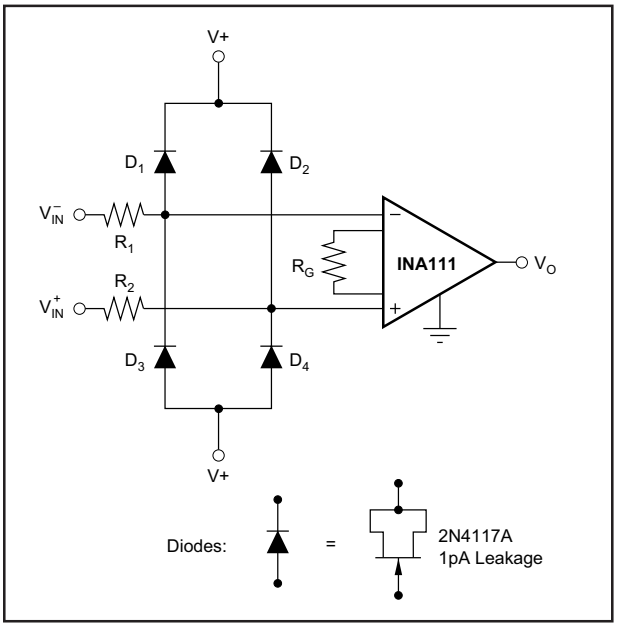


FIGURE 5. Input Protection Voltage Clamp.

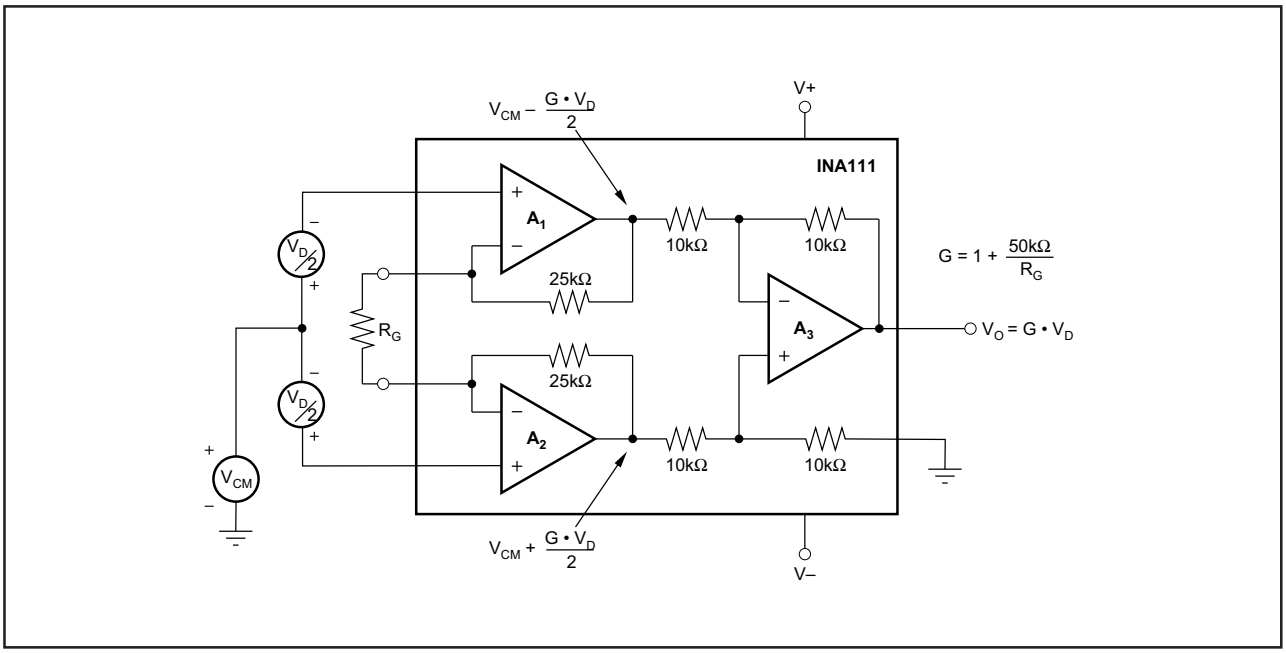


FIGURE 4. Voltage Swing of A_1 and A_2.

mismatched values, causes a high frequency common-mode signal to be converted to a differential signal. This degrades common-mode rejection. The differential input capacitor, C_3, reduces the bandwidth and mitigates the effects of mismatch in C_1 and C_2. Make C_3 much larger than C_1 and C_2. If properly matched, C_1 and C_2 also improve CMR.

OUTPUT VOLTAGE SENSE (SOL-16 Package Only)

The surface-mount version of the INA111 has a separate output sense feedback connection (pin 12). Pin 12 must be connected, usually to the output terminal, pin 11, for proper operation. (This connection is made internally on the DIP version of the INA111.)

The output feedback connection can be used to sense the output voltage directly at the load for best accuracy. Figure 8 shows how to drive a load through series interconnection resistance. Remotely located feedback paths may cause instability. This can be generally be eliminated with a high frequency feedback path through C_1.

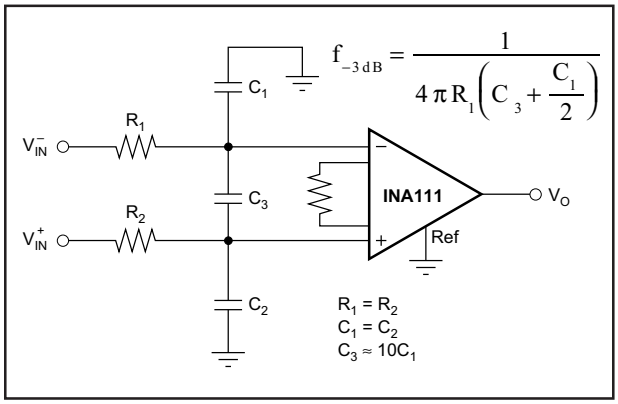


FIGURE 6. Input Low-Pass Filter.

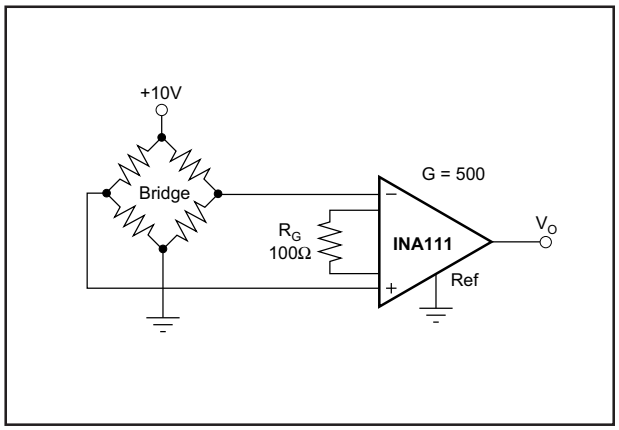


FIGURE 7. Bridge Transducer Amplifier.

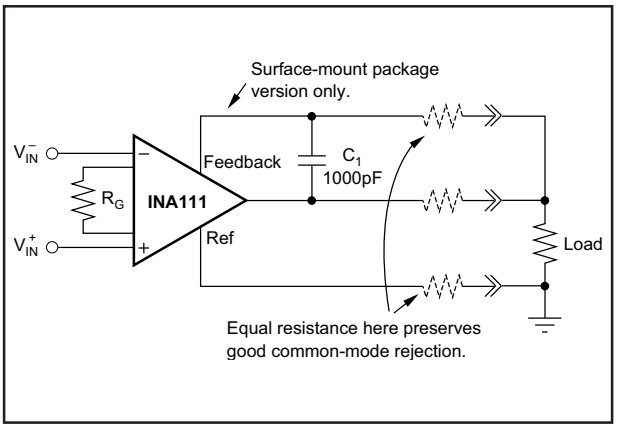


FIGURE 8. Remote Load and Ground Sensing.

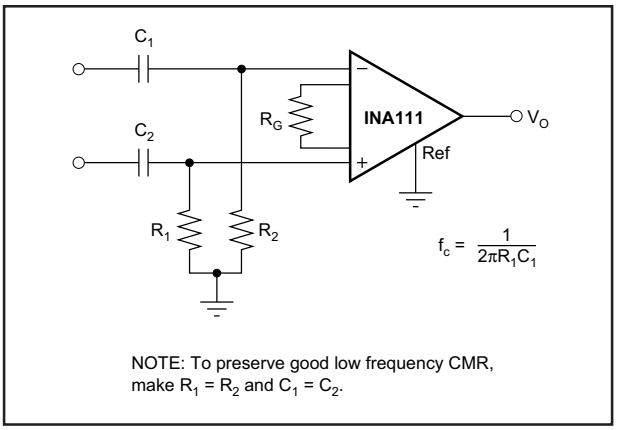


FIGURE 9. High-Pass Input Filter.

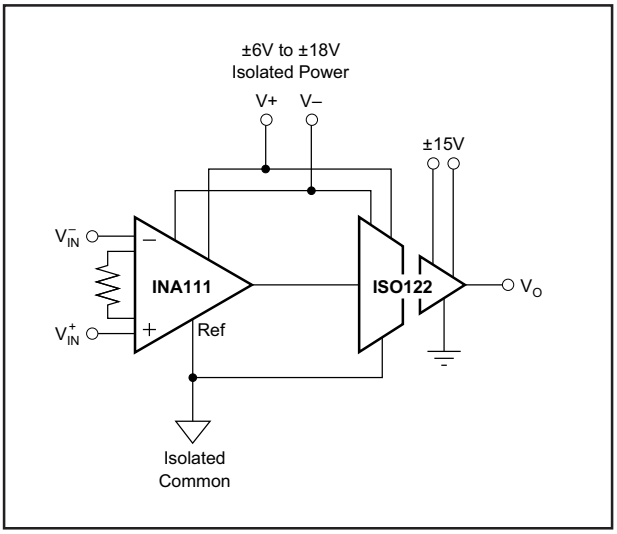


FIGURE 10. Galvanically Isolated Instrumentation Amplifier.

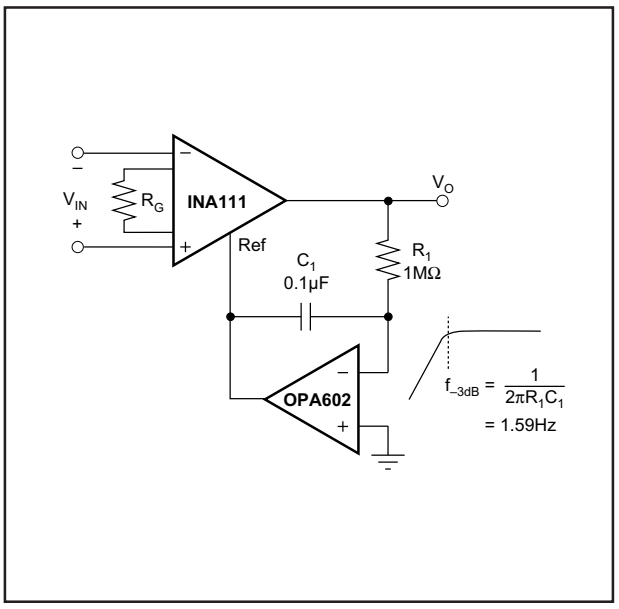


FIGURE 11. AC-Coupled Instrumentation Amplifier.

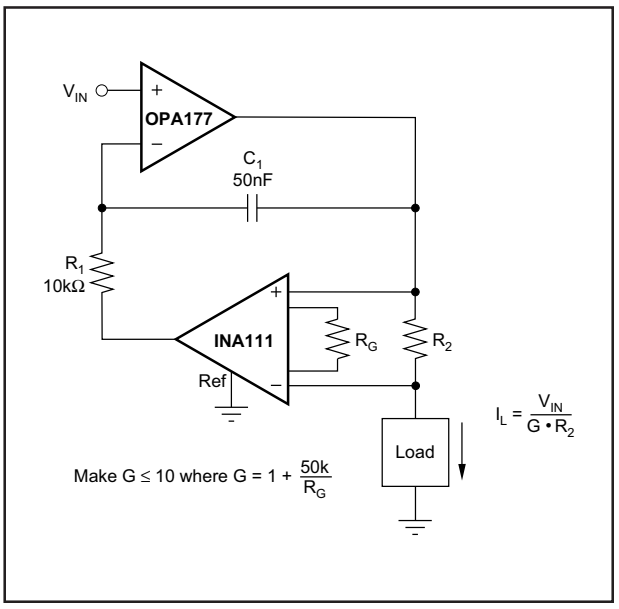


FIGURE 12. Voltage Controlled Current Source.

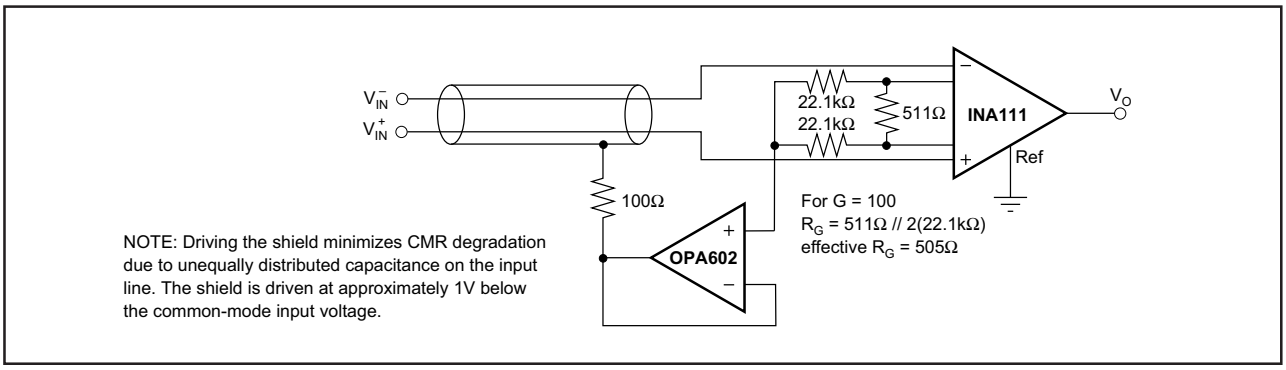


FIGURE 13. Shield Driver Circuit.

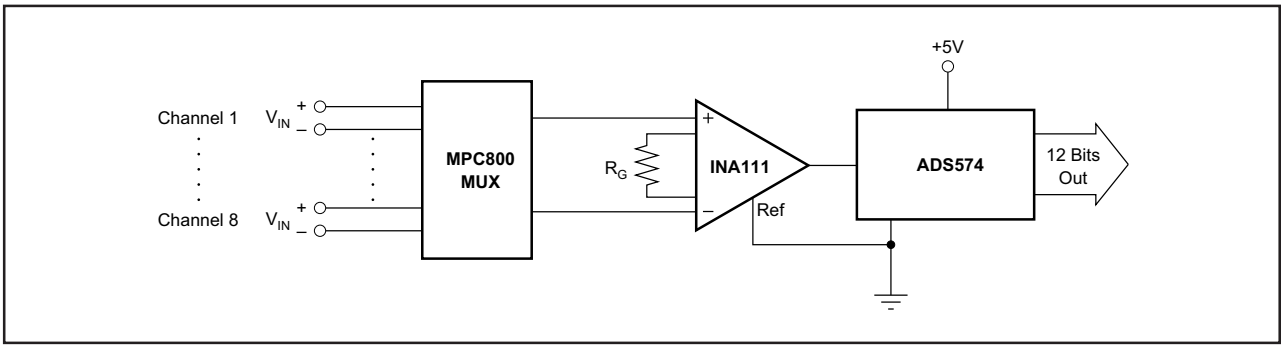


FIGURE 14. Multiplexed-Input Data Acquisition System.

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2002-06-14

ELFA

PRODUKTINFORMATION

Vi reserverar oss mot fel samt förbehåller oss rätten till ändringar utan föregående meddelande

ELFA artikelnr

73-016-82 LM324N quad op-amp DIL14
73-016-90 LM224N quad op-amp DIL14
73-462-24 LM224D op-amp SO14
73-462-32 LM324D op-amp SO14

LM124
LM224 - LM324

LOW POWER QUAD OPERATIONAL AMPLIFIERS

- WIDE GAIN BANDWIDTH : 1.3MHz
- INPUT COMMON-MODE VOLTAGE RANGE INCLUDES GROUND
- LARGE VOLTAGE GAIN : 100dB
- VERY LOW SUPPLY CURRENT/AMPLI : 375µA
- LOW INPUT BIAS CURRENT : 20nA
- LOW INPUT OFFSET VOLTAGE : 5mV max. (for more accurate applications, use the equivalent parts LM124A-LM224A-LM324A which feature 3mV max.)
- LOW INPUT OFFSET CURRENT : 2nA
- WIDE POWER SUPPLY RANGE : SINGLE SUPPLY : +3V TO +30V DUAL SUPPLIES : ±1.5V TO ±15V

N
DIP14
(Plastic Package)

D
SO14
(Plastic Micropackage)

P
TSSOP14
(Thin Shrink Small Outline Package)

DESCRIPTION

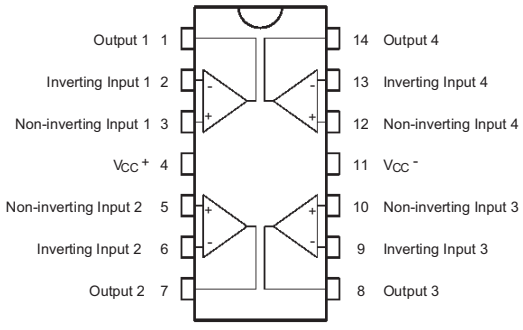
These circuits consist of four independent, high gain, internally frequency compensated operational amplifiers. They operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage.

ORDER CODE

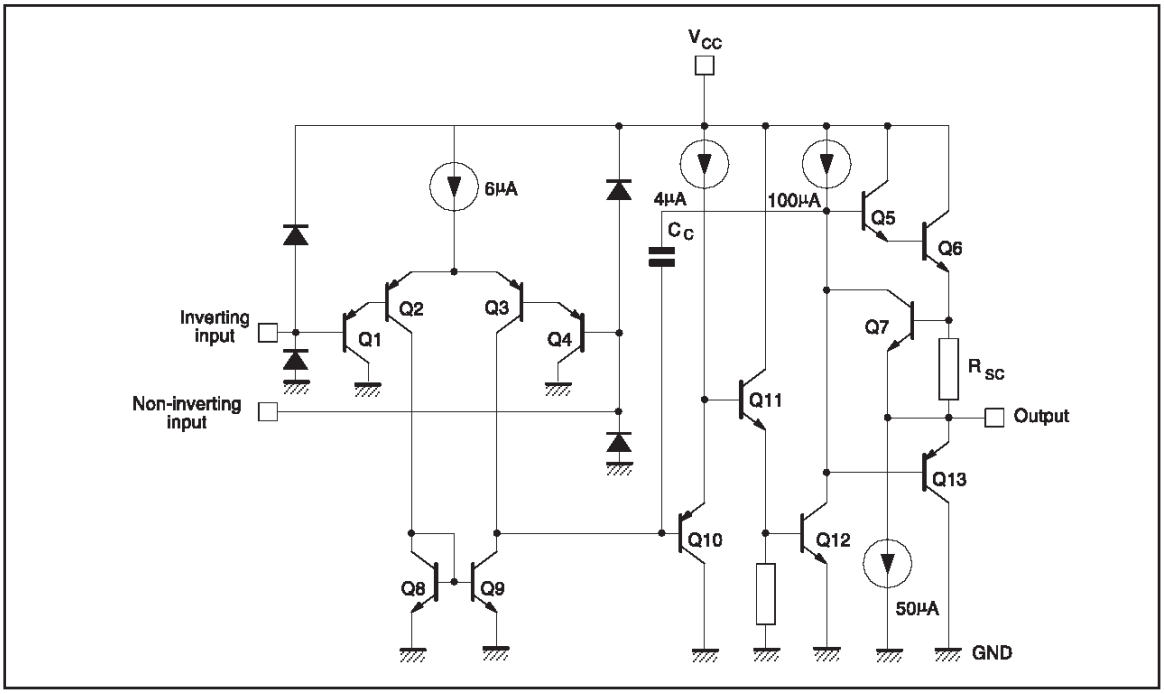
Part Number	Temperature Range	Package		
		N	D	P
LM124	-55°C, +125°C	•	•	•
LM224	-40°C, +105°C	•	•	•
LM324	0°C, +70°C	•	•	•
Example : LM224N				

N = Dual in Line Package (DIP)
D = Small Outline Package (SO) - also available in Tape & Reel (DT)
P = Thin Shrink Small Outline Package (TSSOP) - only available in Tape &Reel (PT)

PIN CONNECTIONS (top view)



SCHEMATIC DIAGRAM (1/4 LM124)



ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	LM124	LM224	LM324	Unit
V_{CC}	Supply voltage	±16 or 32			V
V_i	Input Voltage	-0.3 to +32			V
V_{id}	Differential Input Voltage [1]	+32			V
P_{tot}	Power Dissipation N Suffix D Suffix	500	500 400	500 400	mW mW
	Output Short-circuit Duration [2]	Infinite			
I_{in}	Input Current [3]	50	50	50	mA
T_{oper}	Opearting Free-air Temperature Range	-55 to +125	-40 to +105	0 to +70	°C
T_{stg}	Storage Temperature Range	-65 to +150			°C

1. Either or both input voltages must not exceed the magnitude of V_{CC}^+ or V_{CC}^-.
2. Short-circuits from the output to VCC can cause excessive heating if V_{CC} > 15V. The maximum output current is approximately 40mA independent of the magnitude of V_{CC}. Destructive dissipation can result from simultaneous short-circuit on all amplifiers.
3. This input current only exists when the voltage at any of the input leads is driven negative. It is due to the collector-base junction of the input PNP transistor becoming forward biased and thereby acting as input diodes clamps. In addition to this diode action, there is also NPN parasitic action on the IC chip. this transistor action can cause the output voltages of the Op-amps to go to the V_{CC} voltage level (or to ground for a large overdrive) for the time duration than an input is driven negative.
This is not destructive and normal output will set up again for input voltage higher than -0.3V.

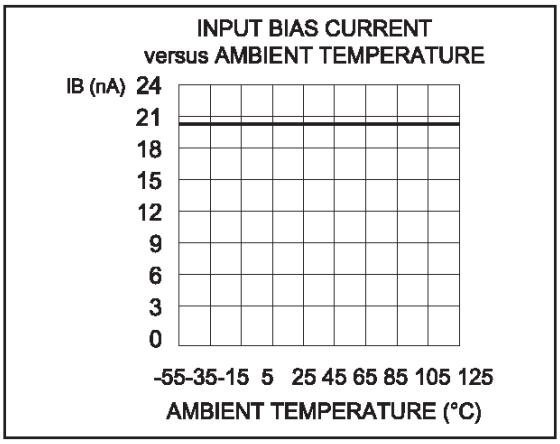
ELECTRICAL CHARACTERISTICS

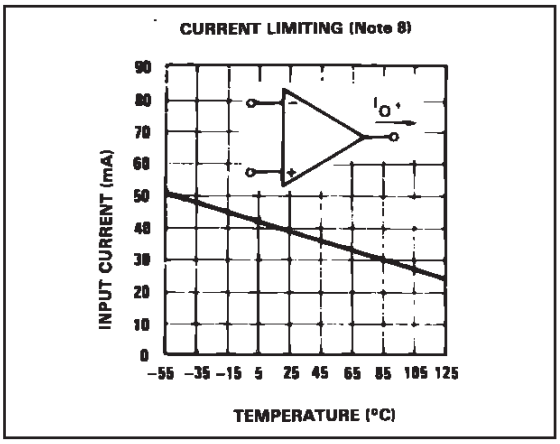
V_{CC}^+ = +5V, V_{CC}^-= Ground, V_o = 1.4V, T_{amb} = +25°C (unless otherwise specified)

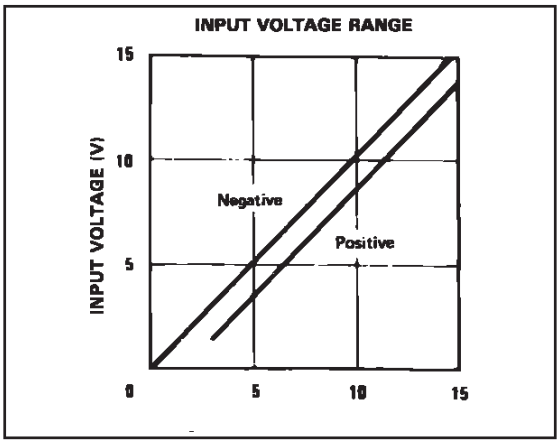
Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{io}	Input Offset Voltage - note 1) T_{amb} = +25°C LM324 $T_{min} \le T_{amb} \le T_{max}$ LM324		2	5 7 7 9	mV
I_{io}	Input Offset Current T_{amb} = +25°C $T_{min} \le T_{amb} \le T_{max}$		2	30 100	nA
I_{ib}	Input Bias Current - note 2) T_{amb} = +25°C $T_{min} \le T_{amb} \le T_{max}$		20	150 300	nA
A_{vd}	Large Signal Voltage Gain V_{CC}^+ = +15V, R_L = 2kΩ, V_o = 1.4V to 11.4V T_{amb} = +25°C $T_{min} \le T_{amb} \le T_{max}$	 50 25	100		V/mV
SVR	Supply Voltage Rejection Ratio ($R_s \le 10k\Omega$) V_{CC}^+ = 5V to 30V T_{amb} = +25°C $T_{min} \le T_{amb} \le T_{max}$	 65 65	110		dB
I_{CC}	Supply Current, all Amp, no load T_{amb} = +25°C V_{CC} = +5V V_{CC} = +30V $T_{min} \le T_{amb} \le T_{max}$ V_{CC} = +5V V_{CC} = +30V		0.7 1.5 0.8 1.5	1.2 3 1.2 3	mA
V_{icm}	Input Common Mode Voltage Range V_{CC} = +30V - note 3) T_{amb} = +25°C $T_{min} \le T_{amb} \le T_{max}$	 0 0		V_{CC} -1.5 V_{CC} -2	V
CMR	Common Mode Rejection Ratio ($R_s \le 10k\Omega$) T_{amb} = +25°C $T_{min} \le T_{amb} \le T_{max}$	 70 60	80		dB
I_{source}	Output Current Source (V_{id} = +1V) V_{CC} = +15V, V_o = +2V	20	40	70	mA
I_{sink}	Output Sink Current (V_{id} = -1V) V_{CC} = +15V, V_o = +2V V_{CC} = +15V, V_o = +0.2V	 10 12	 20 50		mA µA
V_{OH}	High Level Output Voltage V_{CC} = +30V T_{amb} = +25°C R_L = 2kΩ $T_{min} \le T_{amb} \le T_{max}$ T_{amb} = +25°C R_L = 10kΩ $T_{min} \le T_{amb} \le T_{max}$ V_{CC} = +5V, R_L = 2kΩ T_{amb} = +25°C $T_{min} \le T_{amb} \le T_{max}$	 26 26 27 27 3.5 3	 27 28		V

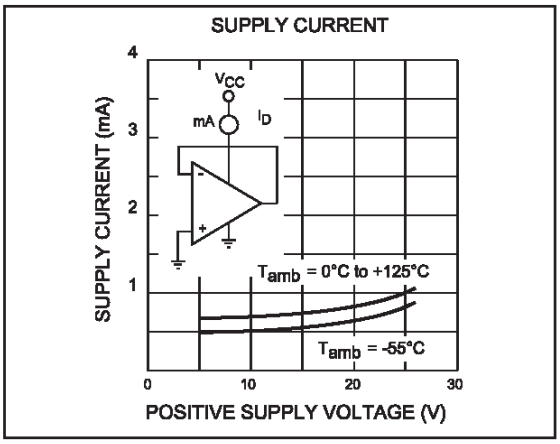
Symbol	Parameter	Min.	Typ.	Max.	Unit
V_{OL}	Low Level Output Voltage (R_L = 10kΩ) T_{amb} = +25°C $T_{min} \le T_{amb} \le T_{max}$		5	20 20	mV
SR	Slew Rate V_{CC} = 15V, V_i = 0.5 to 3V, R_L = 2kΩ, C_L = 100pF, unity Gain		0.4		V/µs
GBP	Gain Bandwidth Product V_{CC} = 30V, f = 100kHz, V_{in} = 10mV, R_L = 2kΩ, C_L = 100pF		1.3		MHz
THD	Total Harmonic Distortion f = 1kHz, A_v = 20dB, R_L = 2kΩ, V_o = $2V_{pp}$, C_L = 100pF, V_{CC} = 30V		0.015		%
e_n	Equivalent Input Noise Voltage f = 1kHz, R_s = 100Ω, V_{CC} = 30V		40		$\frac{nV}{\sqrt{Hz}}$
DV_{io}	Input Offset Voltage Drift		7	30	µV/°C
DI_{lio}	Input Offset Current Drift		10	200	pA/°C
V_{o1}/V_{o2}	Channel Separation - note 4) 1kHz ≤ f ≤ 20kHZ		120		dB

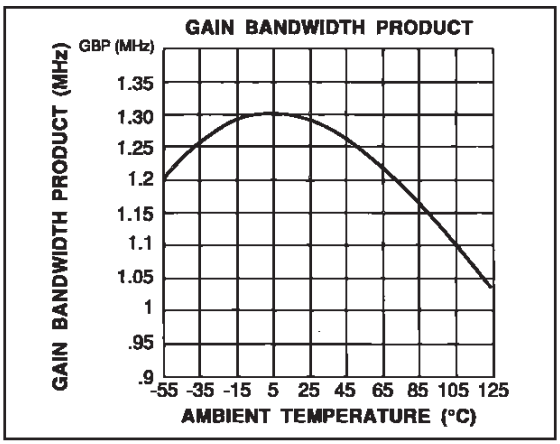
1. V_o = 1.4V, R_s = 0Ω, 5V < V_{CC}^+ < 30V, 0 < V_{ic} < V_{CC}^+ - 1.5V
2. The direction of the input current is out of the IC. This current is essentially constant, independent of the state of the output so no loading change exists on the input lines.
3. The input common-mode voltage of either input signal voltage should not be allowed to go negative by more than 0.3V. The upper end of the common-mode voltage range is V_{CC}^+ - 1.5V, but either or both inputs can go to +32V without damage.
4. Due to the proximity of external components insure that coupling is not originating via stray capacitance between these external parts. This typically can be detected as this type of capacitance increases at higher frequences.

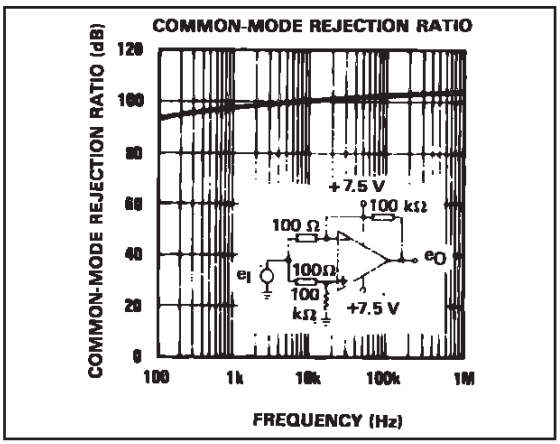

INPUT BIAS CURRENT
versus AMBIENT TEMPERATURE
IB (nA) 24
21
18
15
12
9
6
3
0
-55-35-15 5 25 45 65 85 105 125
AMBIENT TEMPERATURE (°C)


CURRENT LIMITING (Note 8)
INPUT CURRENT (mA)
90
80
70
60
50
40
30
20
10
0
-55 -35 -15 5 25 45 65 85 105 125
TEMPERATURE (°C)

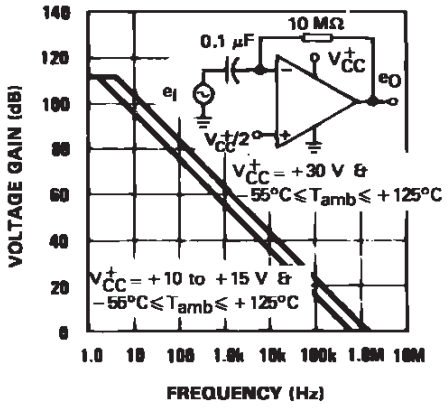

INPUT VOLTAGE RANGE
INPUT VOLTAGE (V)
15
10
5
0
Negative
Positive
0
5
10
15


SUPPLY CURRENT
SUPPLY CURRENT (mA)
4
3
2
1
VCC
mA
ID
Tamb = 0°C to +125°C
Tamb = -55°C
0
10
20
30
POSITIVE SUPPLY VOLTAGE (V)

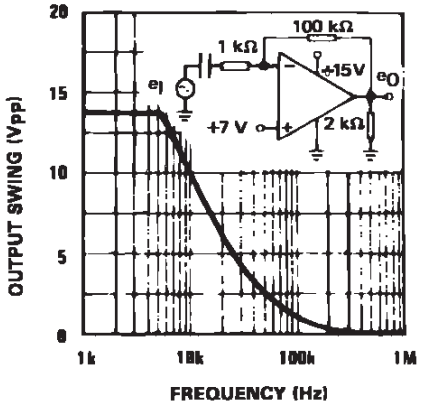

GAIN BANDWIDTH PRODUCT
GBP (MHz)
GAIN BANDWIDTH PRODUCT (MHz)
1.35
1.30
1.25
1.2
1.15
1.1
1.05
1
.95
.9
-55 -35 -15 5 25 45 65 85 105 125
AMBIENT TEMPERATURE (°C)


COMMON-MODE REJECTION RATIO
COMMON-MODE REJECTION RATIO (dB)
120
100
80
60
40
20
0
100
1k
10k
100k
1M
FREQUENCY (Hz)
+7.5 V
100 kΩ
100 Ω
eI
100Ω
100 kΩ
eO
+7.5 V

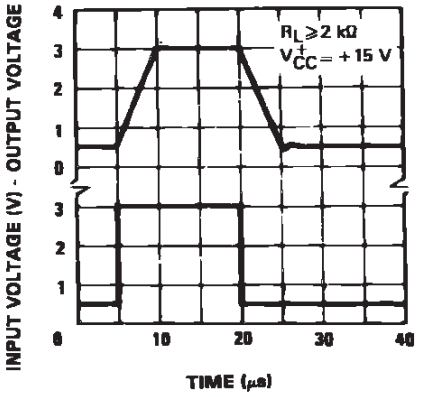
OPEN LOOP FREQUENCY RESPONSE



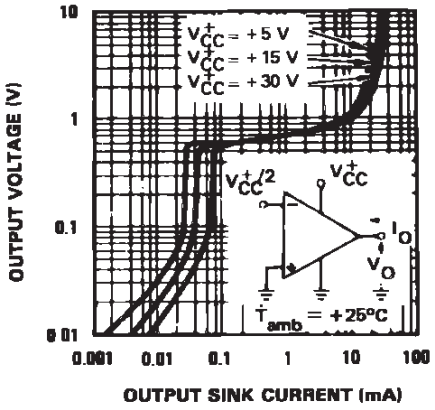
LARGE SIGNAL FREQUENCY RESPONSE



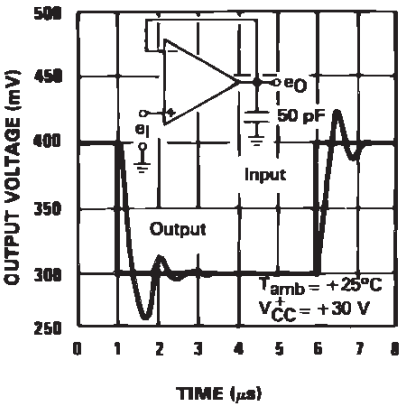
VOLTAGE FOLLOWER PULSE RESPONSE



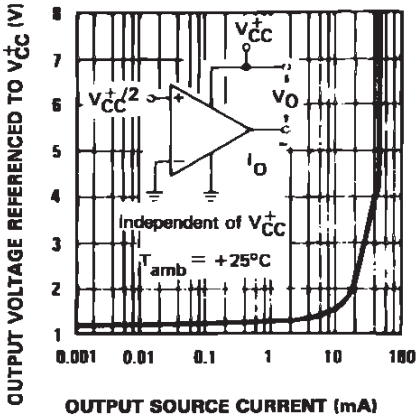
OUTPUT CHARACTERISTICS (CURRENT SINKING)

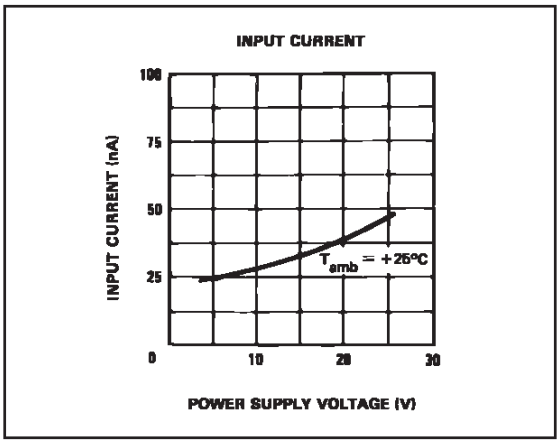


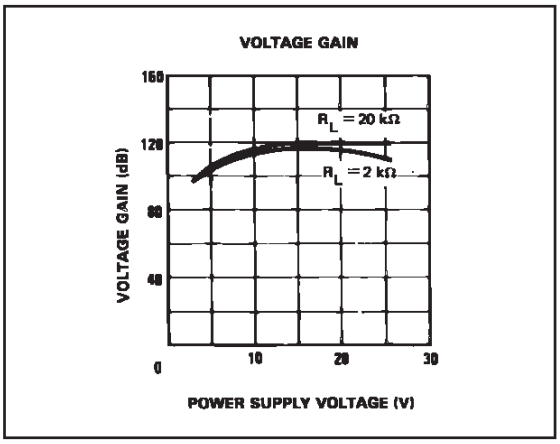
VOLTAGE FOLLOWER PULSE RESPONSE (SMALL SIGNAL)

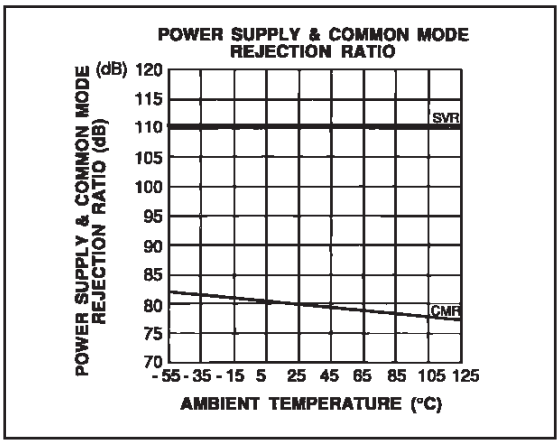


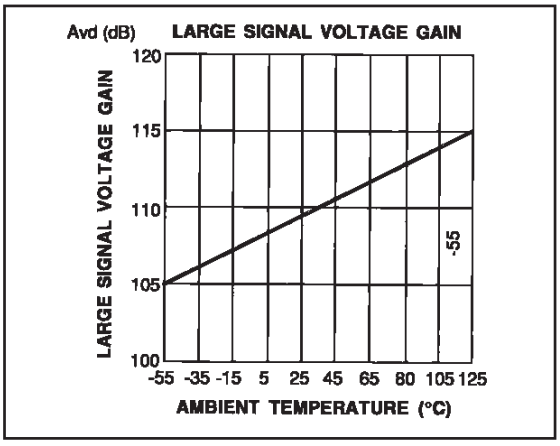
OUTPUT CHARACTERISTICS (CURRENT SOURCING)





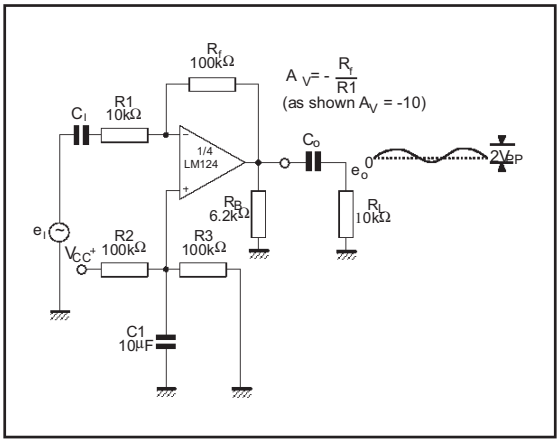




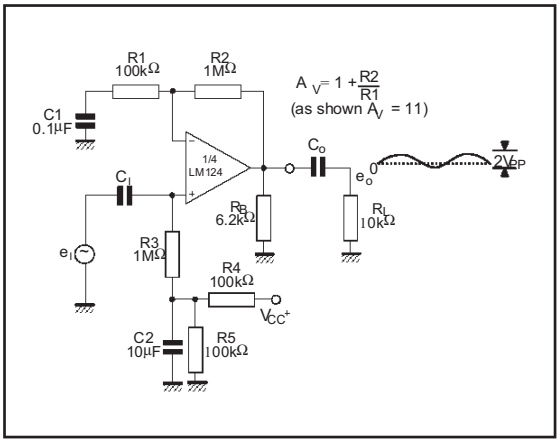


TYPICAL SINGLE - SUPPLY APPLICATIONS

AC COUPLED INVERTING AMPLIFIER

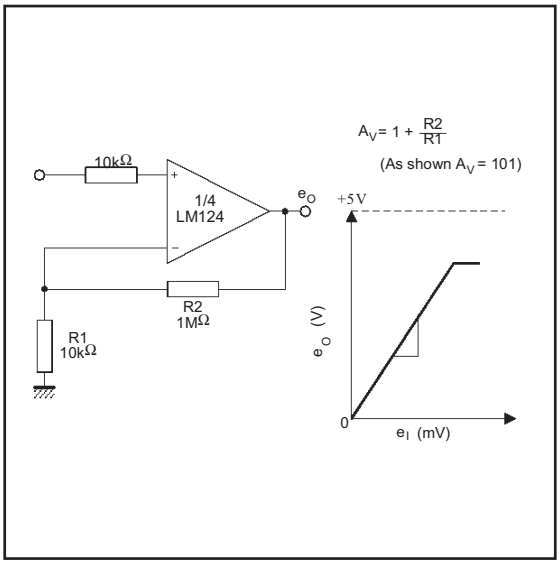


AC COUPLED NON INVERTING AMPLIFIER

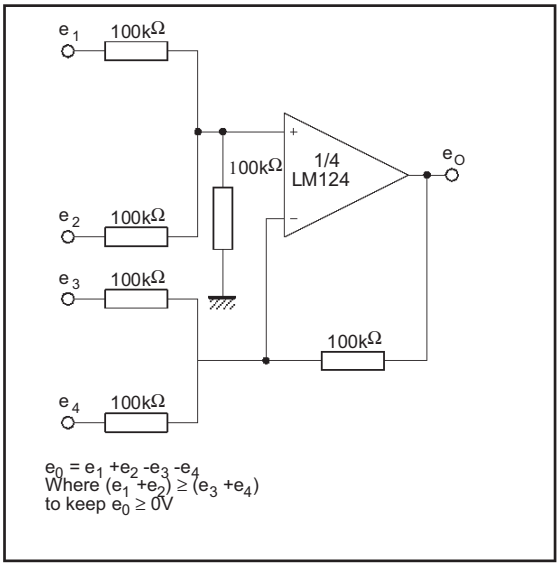


TYPICAL SINGLE - SUPPLY APPLICATIONS

NON-INVERTING DC GAIN

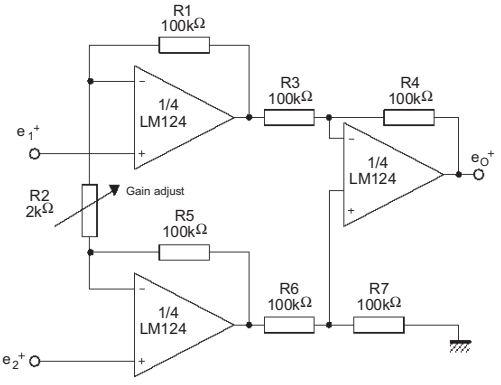


DC SUMMING AMPLIFIER



$e_0 = e_1 + e_2 - e_3 - e_4$
Where $(e_1 + e_2) \geq (e_3 + e_4)$
to keep $e_0 \geq 0V$

HIGH INPUT Z ADJUSTABLE GAIN DC INSTRUMENTATION AMPLIFIER

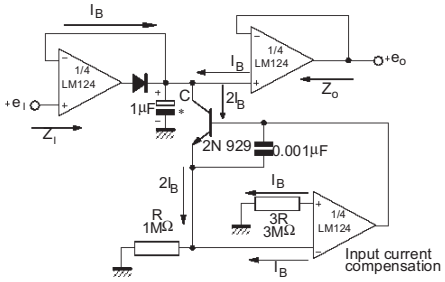


if R1 = R5 and R3 = R4 = R6 = R7

$$e_0 = \left[1 + \frac{2R_1}{R_2}\right](e_2 - e_1)$$

As shown $e_0 = 101\ (e_2 - e_1)$.

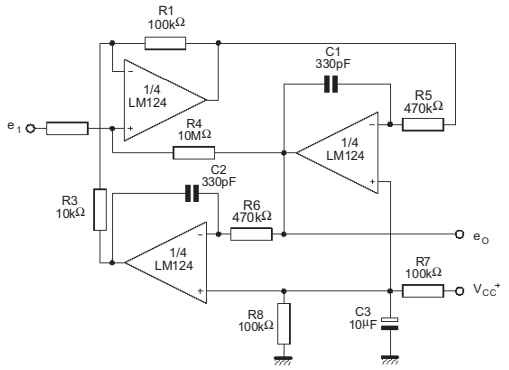
LOW DRIFT PEAK DETECTOR



* Polycarbonate or polyethylene

TYPICAL SINGLE - SUPPLY APPLICATIONS

ACTIVER BANDPASS FILTER



F_o = 1kHz

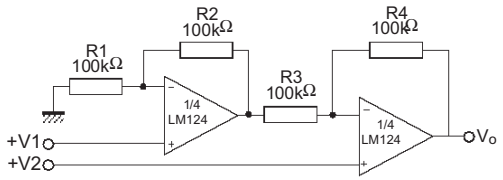
Q = 50

A_v = 100 (40dB)

HIGH INPUT Z, DC DIFFERENTIAL AMPLIFIER

For $\frac{R_1}{R_2} = \frac{R_4}{R_3}$

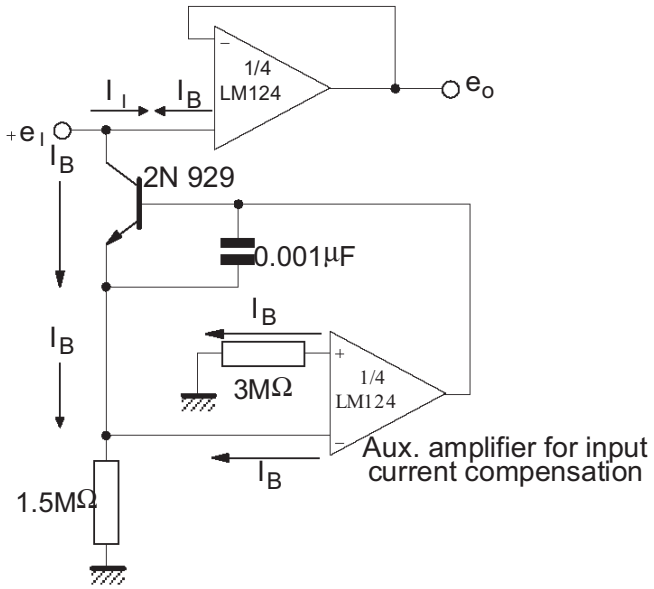
(CMRR depends on this resistor ratio match)



$e_0 \left(1 + \frac{R_4}{R_3}\right) (e_2 - e_1)$

As shown $e_0 = (e_2 - e_1)$

USING SYMETRICAL AMPLIFIERS TO REDUCE INPUT CURRENT (GENERAL CONCEPT)



MACROMODEL
**** Standard Linear Ics Macromodels, 1993.**

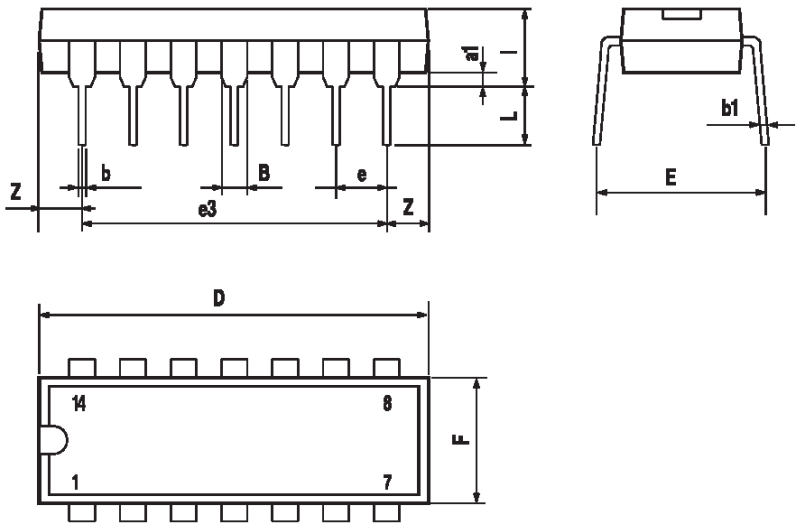
```
** CONNECTIONS :
* 1 INVERTING INPUT
* 2 NON-INVERTING INPUT
* 3 OUTPUT
* 4 POSITIVE POWER SUPPLY
* 5 NEGATIVE POWER SUPPLY

.SUBCKT LM124 1 3 2 4 5 (analog)
**********************************************************
.MODEL MDTH D IS=1E-8 KF=3.104131E-15 CJO=10F
* INPUT STAGE
CIP 2 5 1.000000E-12
CIN 1 5 1.000000E-12
EIP 10 5 2 5 1
EIN 16 5 1 5 1
RIP 10 11 2.600000E+01
RIN 15 16 2.600000E+01
RIS 11 15 2.003862E+02
DIP 11 12 MDTH 400E-12
DIN 15 14 MDTH 400E-12
VOFP 12 13 DC 0
VOFN 13 14 DC 0
IPOL 13 5 1.000000E-05
CPS 11 15 3.783376E-09
DINN 17 13 MDTH 400E-12
VIN 17 5 0.000000e+00
DINR 15 18 MDTH 400E-12
VIP 4 18 2.000000E+00
FCP 4 5 VOFP 3.400000E+01
FCN 5 4 VOFN 3.400000E+01
FIBP 2 5 VOFN 2.000000E-03
FIBN 5 1 VOFP 2.000000E-03
* AMPLIFYING STAGE
FIP 5 19 VOFP 3.600000E+02
FIN 5 19 VOFN 3.600000E+02
RG1 19 5 3.652997E+06
RG2 19 4 3.652997E+06
CC 19 5 6.000000E-09
DOPM 19 22 MDTH 400E-12
DONM 21 19 MDTH 400E-12
HOPM 22 28 VOUT 7.500000E+03
VIPM 28 4 1.500000E+02
HONM 21 27 VOUT 7.500000E+03
VINM 5 27 1.500000E+02
EOUT 26 23 19 5 1
VOUT 23 5 0
ROUT 26 3 20
COUT 3 5 1.000000E-12
DOP 19 25 MDTH 400E-12
VOP 4 25 2.242230E+00
DON 24 19 MDTH 400E-12
VON 24 5 7.922301E-01
.ENDS
```

ELECTRICAL CHARACTERISTICS
V_{cc}^+ = +15V, V_{cc}^- = 0V, T_{amb} = 25°C (unless otherwise specified)

Symbol	Conditions	Value	Unit
V_{io}		0	mV
A_{vd}	R_L = 2kΩ	100	V/mV
I_{cc}	No load, per amplifier	350	µA
V_{icm}		-15 to +13.5	V
V_{OH}	R_L = 2kΩ (V_{CC}^+=15V)	+13.5	V
V_{OL}	R_L = 10kΩ	5	mV
I_{os}	V_o = +2V, V_{CC} = +15V	+40	mA
GBP	R_L = 2kΩ, C_L = 100pF	1.3	MHz
SR	R_L = 2kΩ, C_L = 100pF	0.4	V/µs

PACKAGE MECHANICAL DATA

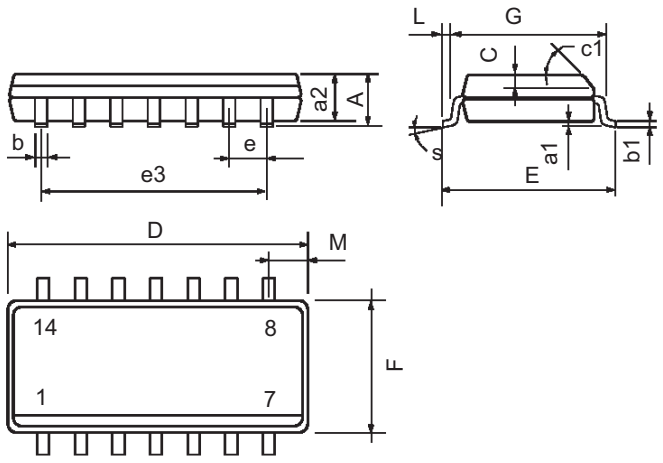
14 PINS - PLASTIC DIP



Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
a1	0.51			0.020		
B	1.39		1.65	0.055		0.065
b		0.5			0.020	
b1		0.25			0.010	
D			20			0.787
E		8.5			0.335	
e		2.54			0.100	
e3		15.24			0.600	
F			7.1			0.280
i			5.1			0.201
L		3.3			0.130	
Z	1.27		2.54	0.050		0.100

PACKAGE MECHANICAL DATA

14 PINS - PLASTIC MICROPACKAGE (SO)

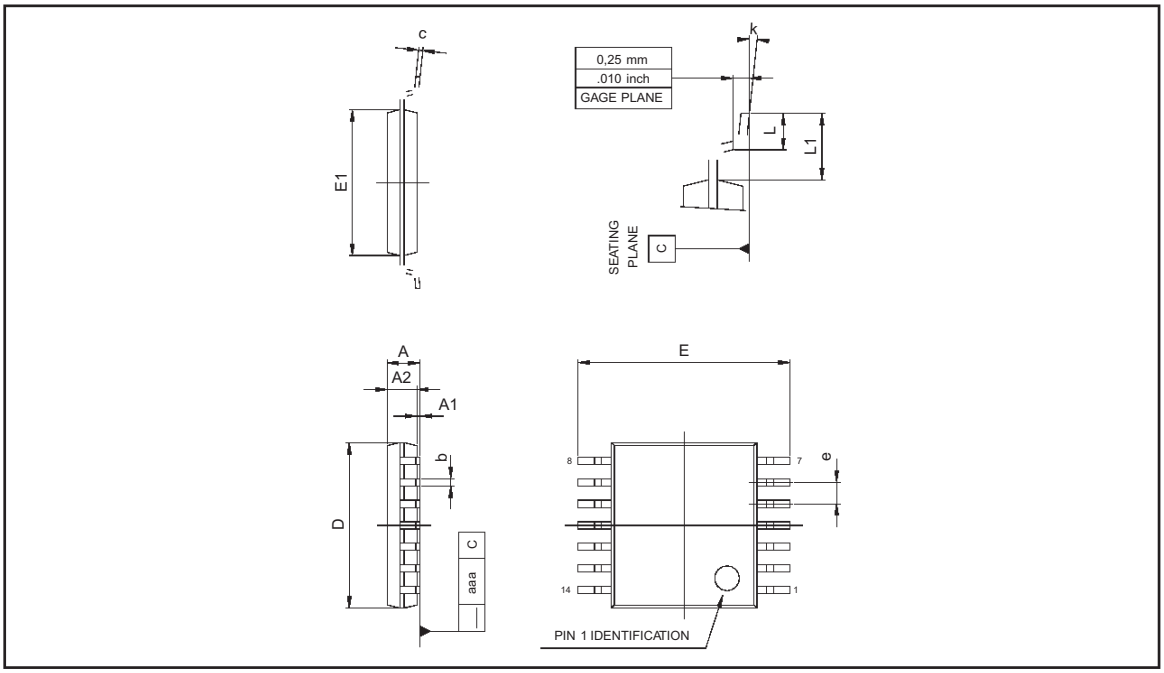


Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.75			0.069
a1	0.1		0.2	0.004		0.008
a2			1.6			0.063
b	0.35		0.46	0.014		0.018
b1	0.19		0.25	0.007		0.010
C		0.5			0.020	
c1	45° (typ.)					
D (1)	8.55		8.75	0.336		0.344
E	5.8		6.2	0.228		0.244
e		1.27			0.050	
e3		7.62			0.300	
F (1)	3.8		4.0	0.150		0.157
G	4.6		5.3	0.181		0.208
L	0.5		1.27	0.020		0.050
M			0.68			0.027
S	8° (max.)					

Note : (1) D and F do not include mold flash or protrusions - Mold flash or protrusions shall not exceed 0.15mm (.066 inc) ONLY FOR DATA BOOK.

PACKAGE MECHANICAL DATA

14 PINS - THIN SHRINK SMALL OUTLINE PACKAGE (TSSOP)



Dimensions	Millimeters			Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.
A			1.20			0.05
A1	0.05		0.15	0.01		0.006
A2	0.80	1.00	1.05	0.031	0.039	0.041
b	0.19		0.30	0.007		0.15
c	0.09		0.20	0.003		0.012
D	4.90	5.00	5.10	0.192	0.196	0.20
E		6.40			0.252	
E1	4.30	4.40	4.50	0.169	0.173	0.177
e		0.65			0.025	
k	0°		8°	0°		8°
L	0.450	0.600	0.750	0.018	0.024	0.030
L1		1.00			0.039	
aaa			0.100			0.004

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National Semiconductor

July 1999

LM341/LM78MXX Series
3-Terminal Positive Voltage Regulators

General Description

The LM341 and LM78MXX series of three-terminal positive voltage regulators employ built-in current limiting, thermal shutdown, and safe-operating area protection which makes them virtually immune to damage from output overloads.

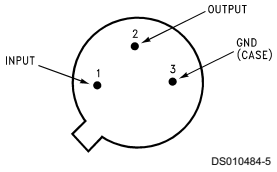
With adequate heatsinking, they can deliver in excess of 0.5A output current. Typical applications would include local (on-card) regulators which can eliminate the noise and degraded performance associated with single-point regulation.

Features

- Output current in excess of 0.5A
- No external components
- Internal thermal overload protection
- Internal short circuit current-limiting
- Output transistor safe-area compensation
- Available in TO-220, TO-39, and TO-252 D-PAK packages
- Output voltages of 5V, 12V, and 15V

Connection Diagrams

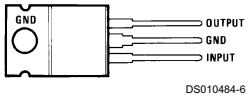
TO-39 Metal Can Package (H)



DS010484-5

Bottom View
Order Number LM78M05CH, LM78M12CH or LM78M15CH
See NS Package Number H03A

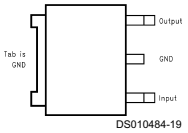
TO-220 Power Package (T)



DS010484-6

Top View
Order Number LM341T-5.0, LM341T-12, LM341T-15, LM78M05CT, LM78M12CT or LM78M15CT
See NS Package Number T03B

TO-252



DS010484-19

Top View
Order Number LM78M05CDT
See NS Package Number TD03B

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Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

Lead Temperature (Soldering, 10 seconds)	
TO-39 Package (H)	300˚C
TO-220 Package (T)	260˚C
Storage Temperature Range	−65˚C to +150˚C
Operating Junction Temperature Range	−40˚C to +125˚C
Power Dissipation (Note 2)	Internally Limited
Input Voltage	
$5V \le V_O \le 15V$	35V
ESD Susceptibility	TBD

Electrical Characteristics

Limits in standard typeface are for T_J = 25˚C, and limits in **boldface type** apply over the −40˚C to +125˚C operating temperature range. Limits are guaranteed by production testing or correlation techniques using standard Statistical Quality Control (SQC) methods.

LM341-5.0, LM78M05C

Unless otherwise specified: V_{IN} = 10V, C_{IN} = 0.33 µF, C_O = 0.1 µF

Symbol	Parameter	Conditions		Min	Typ	Max	Units
V_O	Output Voltage	I_L = 500 mA		4.8	5.0	5.2	V
		5 mA ≤ I_L ≤ 500 mA $P_D \le 7.5W$, $7.5V \le V_{IN} \le 20V$		**4.75**	**5.0**	**5.25**	
$V_{R\ LINE}$	Line Regulation	$7.2V \le V_{IN} \le 25V$	I_L = 100 mA			50	mV
			I_L = 500 mA			100	
$V_{R\ LOAD}$	Load Regulation	5 mA ≤ I_L ≤ 500 mA				100	
I_Q	Quiescent Current	I_L = 500 mA			4	10.0	mA
ΔI_Q	Quiescent Current Change	5 mA ≤ I_L ≤ 500 mA				0.5	
		$7.5V \le V_{IN} \le 25V$, I_L = 500 mA				1.0	
V_n	Output Noise Voltage	f = 10 Hz to 100 kHz			40		µV
$\frac{\Delta V_{IN}}{\Delta V_O}$	Ripple Rejection	f = 120 Hz, I_L = 500 mA			78		dB
V_{IN}	Input Voltage Required to Maintain Line Regulation	I_L = 500 mA		7.2			V
ΔV_O	Long Term Stability	I_L = 500 mA				**20**	mV/khrs

Electrical Characteristics

Limits in standard typeface are for T_J = 25˚C, and limits in **boldface type** apply over the −40˚C to +125˚C operating temperature range. Limits are guaranteed by production testing or correlation techniques using standard Statistical Quality Control (SQC) methods. (Continued)

LM341-12, LM78M12C

Unless otherwise specified: V_{IN} = 19V, C_{IN} = 0.33 µF, C_O = 0.1 µF

Symbol	Parameter	Conditions		Min	Typ	Max	Units
V_O	Output Voltage	I_L= 500 mA		11.5	12	12.5	V
		5 mA ≤ I_L ≤ 500 mA P_D ≤ 7.5W, 14.8V ≤ V_{IN} ≤ 27V		**11.4**	**12**	**12.6**	
$V_{R\ LINE}$	Line Regulation	14.5V ≤ V_{IN} ≤ 30V	I_L = 100 mA			120	mV
			I_L = 500 mA			240	
$V_{R\ LOAD}$	Load Regulation	5 mA ≤ I_L ≤ 500 mA				240	
I_Q	Quiescent Current	I_L = 500 mA			4	10.0	mA
ΔI_Q	Quiescent Current Change	5 mA ≤ I_L ≤ 500 mA				0.5	
		14.8V ≤ V_{IN} ≤ 30V, I_L = 500 mA				1.0	
V_n	Output Noise Voltage	f = 10 Hz to 100 kHz			75		µV
$\frac{\Delta V_{IN}}{\Delta V_O}$	Ripple Rejection	f = 120 Hz, I_L = 500 mA			71		dB
V_{IN}	Input Voltage Required to Maintain Line Regulation	I_L = 500 mA		14.5			V
ΔV_O	Long Term Stability	I_L = 500 mA				**48**	mV/khrs

LM341-15, LM78M15C

Unless otherwise specified: V_{IN} = 23V, C_{IN} = 0.33 µF, C_O = 0.1 µF

Symbol	Parameter	Conditions		Min	Typ	Max	Units
V_O	Output Voltage	I_L= 500 mA		14.4	15	15.6	V
		5 mA ≤ I_L ≤ 500 mA P_D ≤ 7.5W, 18V ≤ V_{IN} ≤ 30V		**14.25**	**15**	**15.75**	
$V_{R\ LINE}$	Line Regulation	17.6V ≤ V_{IN} ≤ 30V	I_L = 100 mA			150	mV
			I_L = 500 mA			300	
$V_{R\ LOAD}$	Load Regulation	5 mA ≤ I_L ≤ 500 mA				300	
I_Q	Quiescent Current	I_L = 500 mA			4	10.0	mA
ΔI_Q	Quiescent Current Change	5 mA ≤ I_L ≤ 500 mA				0.5	
		18V ≤ V_{IN} ≤ 30V, I_L = 500 mA				1.0	
V_n	Output Noise Voltage	f = 10 Hz to 100 kHz			90		µV
$\frac{\Delta V_{IN}}{\Delta V_O}$	Ripple Rejection	f = 120 Hz, I_L = 500 mA			69		dB
V_{IN}	Input Voltage Required to Maintain Line Regulation	I_L = 500 mA		17.6			V
ΔV_O	Long Term Stability	I_L = 500 mA				**60**	mV/khrs

Note 1: Absolute maximum ratings indicate limits beyond which damage to the component may occur. Electrical specifications do not apply when operating the device outside of its rated operating conditions.

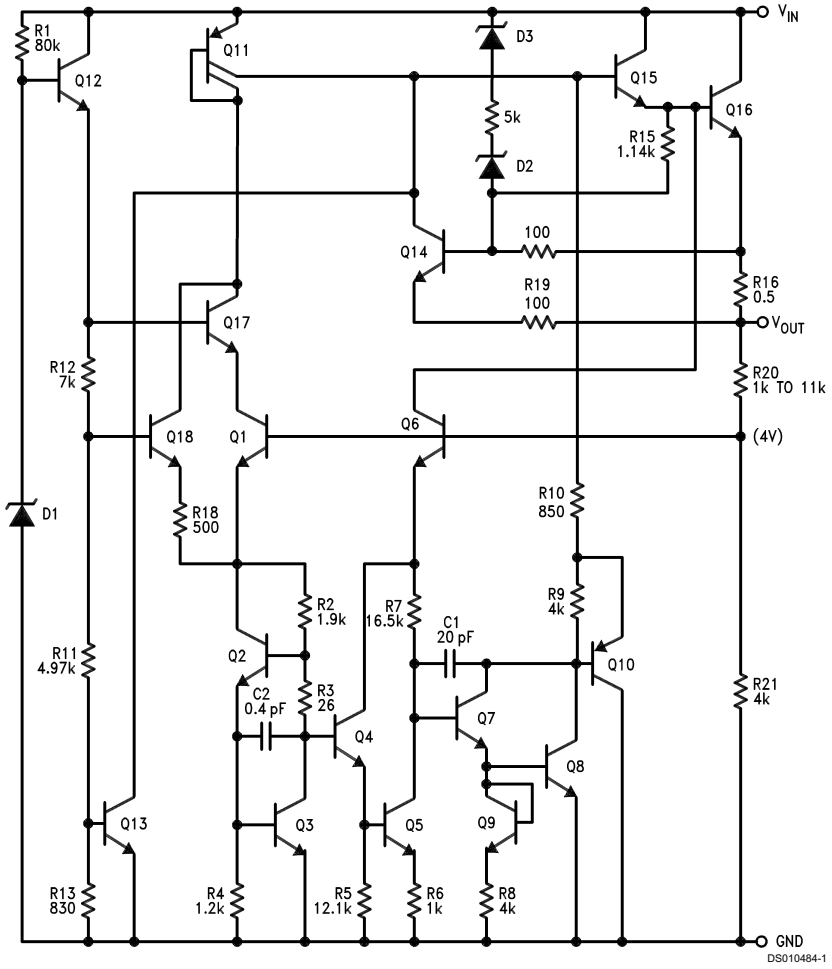
Note 2: The typical thermal resistance of the three package types is:

T (TO-220) package: $\theta_{(JA)}$ = 60 ˚C/W, $\theta_{(JC)}$ = 5 ˚C/W

H (TO-39) package: $\theta_{(JA)}$ = 120 ˚C/W, $\theta_{(JC)}$ = 18 ˚C/W

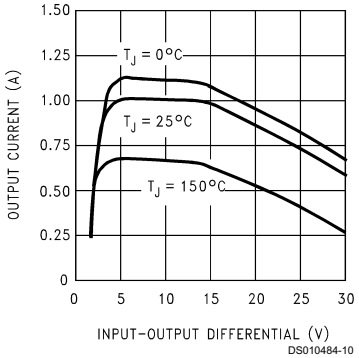
DT (TO-252) package: $\theta_{(JA)}$ = 92 ˚C/W, $\theta_{(JC)}$ = 10 ˚C/W

Schematic Diagram



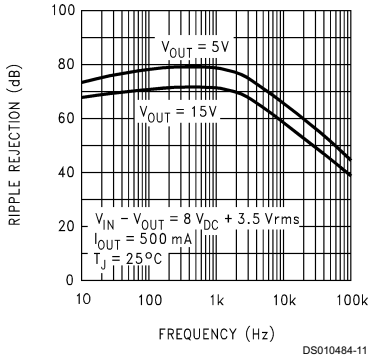
Typical Performance Characteristics

Peak Output Current



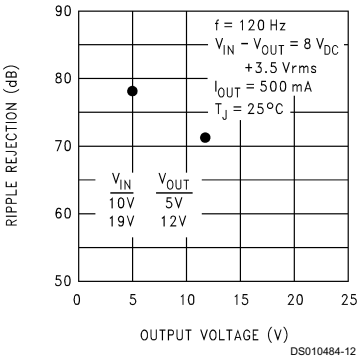
DS010484-10

Ripple Rejection



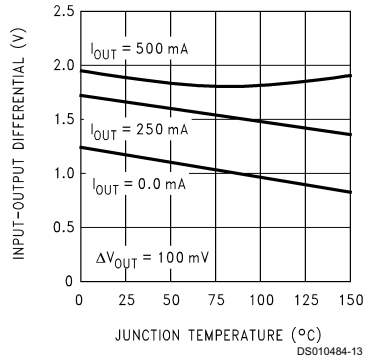
DS010484-11

Ripple Rejection



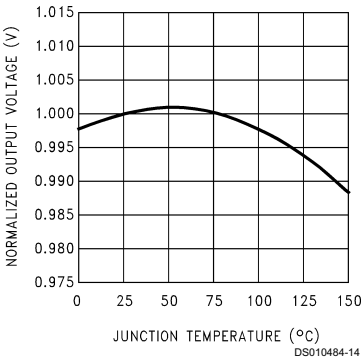
DS010484-12

Dropout Voltage



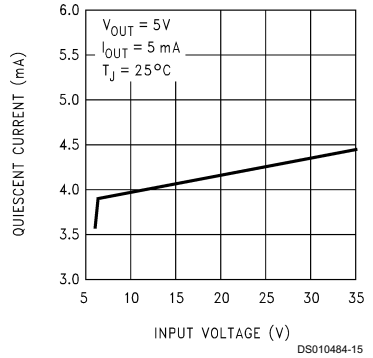
DS010484-13

Output Voltage (Normalized to 1V at T_J = 25°C)



DS010484-14

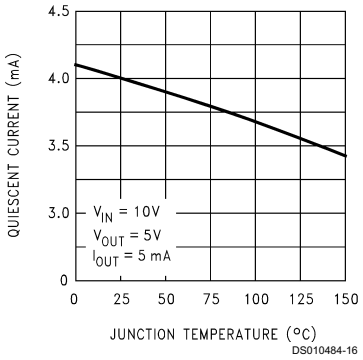
Quiescent Current



DS010484-15

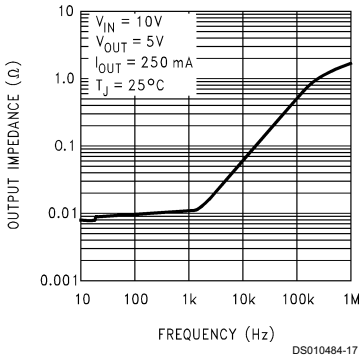
Typical Performance Characteristics (Continued)

Quiescent Current



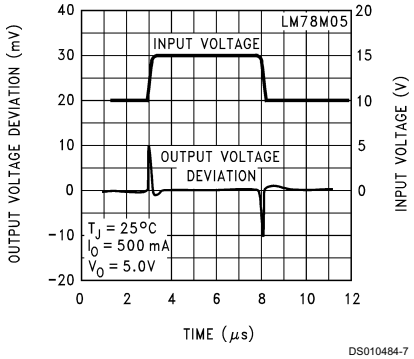
DS010484-16

Output Impedance



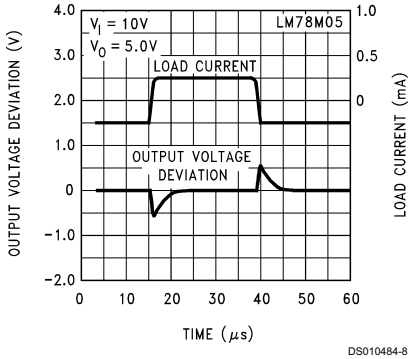
DS010484-17

Line Transient Response



DS010484-7

Load Transient Response



DS010484-8

Design Considerations

The LM78MXX/LM341XX fixed voltage regulator series has built-in thermal overload protection which prevents the device from being damaged due to excessive junction temperature.

The regulators also contain internal short-circuit protection which limits the maximum output current, and safe-area protection for the pass transistor which reduces the short-circuit current as the voltage across the pass transistor is increased.

Although the internal power dissipation is automatically limited, the maximum junction temperature of the device must be kept below +125˚C in order to meet data sheet specifications. An adequate heatsink should be provided to assure this limit is not exceeded under worst-case operating conditions (maximum input voltage and load current) if reliable performance is to be obtained).

1.0 Heatsink Considerations

When an integrated circuit operates with appreciable current, its junction temperature is elevated. It is important to quantify its thermal limits in order to achieve acceptable performance and reliability. This limit is determined by summing the individual parts consisting of a series of temperature rises from the semiconductor junction to the operating environment. A one-dimension steady-state model of conduction heat transfer is demonstrated in The heat generated at the device junction flows through the die to the die attach pad, through the lead frame to the surrounding case material, to the printed circuit board, and eventually to the ambient environment. Below is a list of variables that may affect the thermal resistance and in turn the need for a heatsink.

$R^{\theta JC}$(Component Variables)	$R^{\theta CA}$(Application Variables)
Leadframe Size & Material	Mounting Pad Size, Material, & Location
No. of Conduction Pins	Placement of Mounting Pad
Die Size	PCB Size & Material
Die Attach Material	Traces Length & Width
Molding Compound Size and Material	Adjacent Heat Sources
	Volume of Air
	Air Flow
	Ambient Temperature
	Shape of Mounting Pad

Design Considerations (Continued)

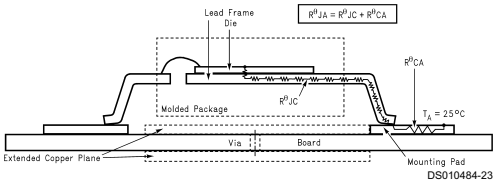


FIGURE 1. Cross-sectional view of Integrated Circuit Mounted on a printed circuit board. Note that the case temperature is measured at the point where the leads contact with the mounting pad surface

The LM78MXX/LM341XX regulators have internal thermal shutdown to protect the device from over-heating. Under all possible operating conditions, the junction temperature of the LM78MXX/LM341XX must be within the range of 0˚C to 125˚C. A heatsink may be required depending on the maximum power dissipation and maximum ambient temperature of the application. To determine if a heatsink is needed, the power dissipated by the regulator, P_D, must be calculated:

$I_{IN} = I_L + I_G$

$P_D = (V_{IN} - V_{OUT})\, I_L + V_{IN} I_G$

shows the voltages and currents which are present in the circuit.

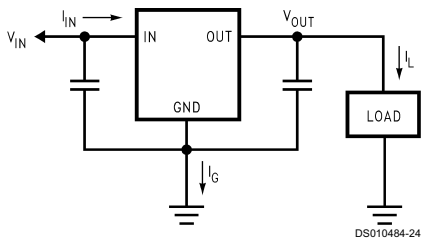


FIGURE 2. Power Dissipation Diagram

The next parameter which must be calculated is the maximum allowable temperature rise, T_R(max):

$\theta_{JA} = TR\ (max)/P_D$

If the maximum allowable value for θ_{JA}˚C/w is found to be ≥60˚C/W for TO-220 package or ≥92˚C/W for TO-252 package, no heatsink is needed since the package alone will dissipate enough heat to satisfy these requirements. If the calculated value for θ_{JA} fall below these limits, a heatsink is required.

As a design aid, *Table 1* shows the value of the θ_{JA} of TO-252 for different heatsink area. The copper patterns that we used to measure these θ_{JA} are shown at the end of the Application Note Section. reflects the same test results as what are in the *Table 1*

shows the maximum allowable power dissipation vs. ambient temperature for theTO-252 device. shows the maximum allowable power dissipation vs. copper area (in^2) for the TO-252 device. Please see AN1028 for power enhancement techniques to be used with TO-252 package.

TABLE 1. θ_{JA} Different Heatsink Area

Layout	Copper Area		Thermal Resistance
	Top Sice (in^2)*	Bottom Side (in^2)	(θ_{JA}, ˚C/W) TO-252
1	0.0123	0	103
2	0.066	0	87
3	0.3	0	60
4	0.53	0	54
5	0.76	0	52
6	1	0	47
7	0	0.2	84
8	0	0.4	70
9	0	0.6	63
10	0	0.8	57
11	0	1	57
12	0.066	0.066	89
13	0.175	0.175	72
14	0.284	0.284	61
15	0.392	0.392	55
16	0.5	0.5	53

*Tab of device attached to topside copper

Design Considerations (Continued)

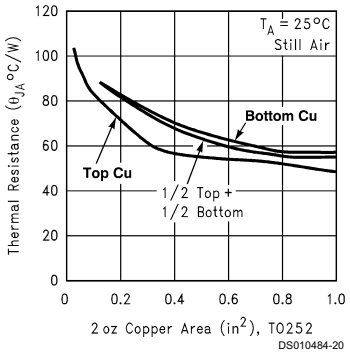


FIGURE 3. θ_{JA} vs. 2oz Copper Area for TO-252

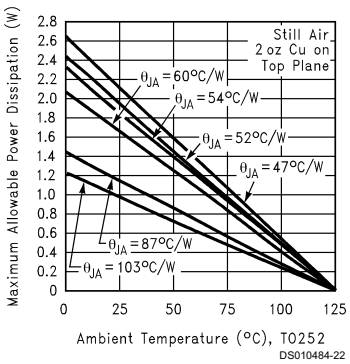


FIGURE 4. Maximum Allowable Power Dissipation vs. Ambient Temperature for TO-252

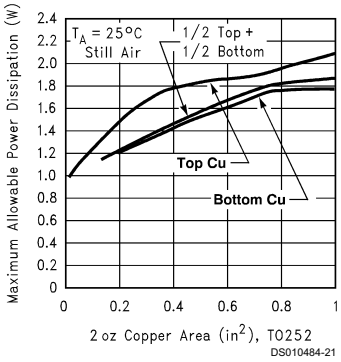
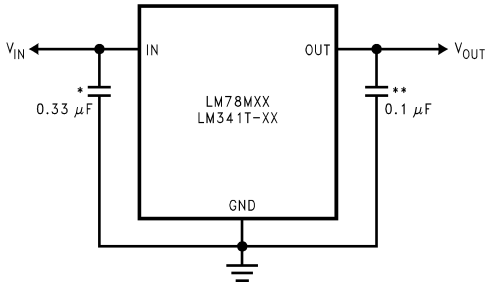


FIGURE 5. Maximum Allowable Power Dissipation vs. 2oz. Copper Area for TO-252

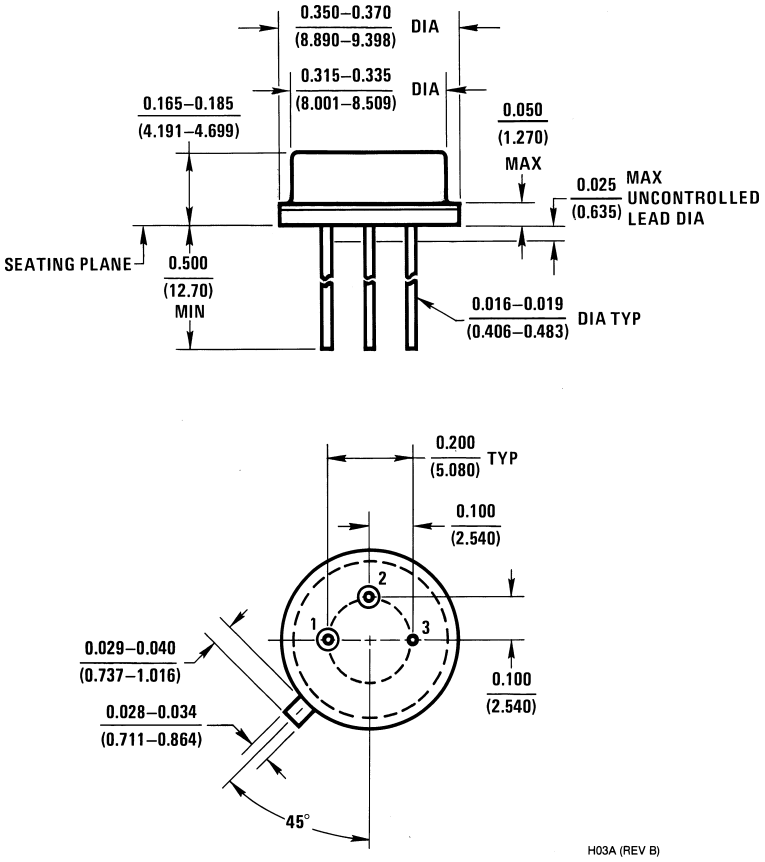
Typical Application



*Required if regulator input is more than 4 inches from input filter capacitor (or if no input filter capacitor is used).

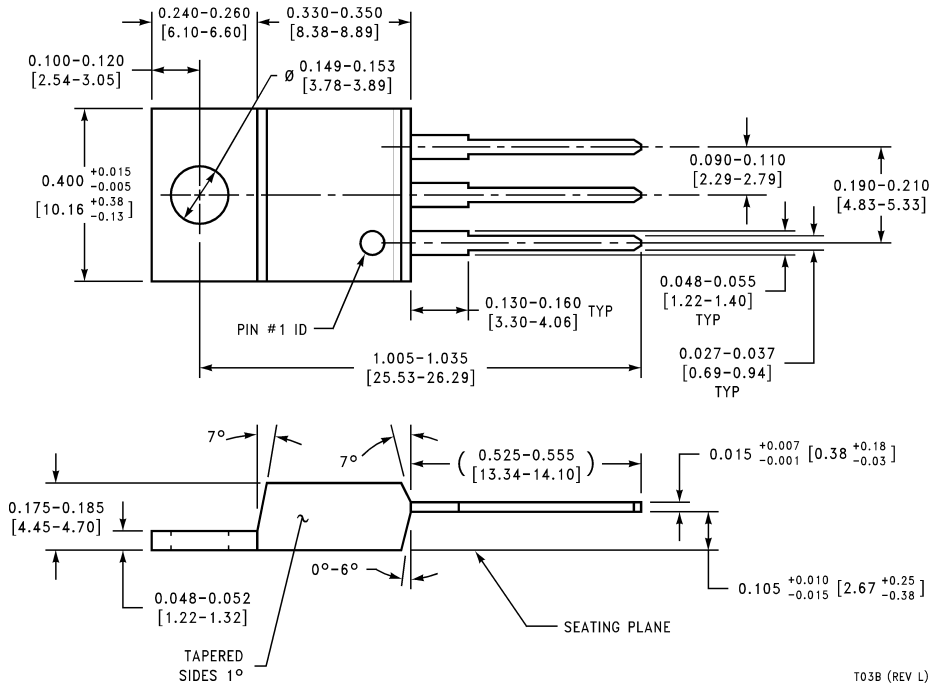
**Optional for improved transient response.

Physical Dimensions inches (millimeters) unless otherwise noted



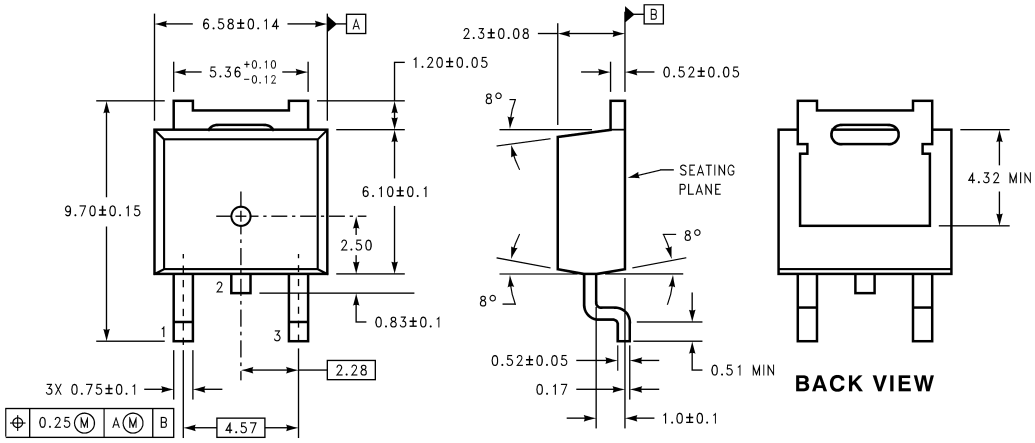
TO-39 Metal Can Package (H)
Order Number LM78M05CH, LM78M12CH or LM78M15CH
NS Package Number H03A

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



TO-220 Power Package (T)
Order Number LM341T-5.0, LM341T-12, LM341T-15, LM78M05CT, LM78M12CT or LM78M15CT
NS Package Number T03B

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



TO-252
Order Number LM78M05CDT
NS Package Number TD03B

LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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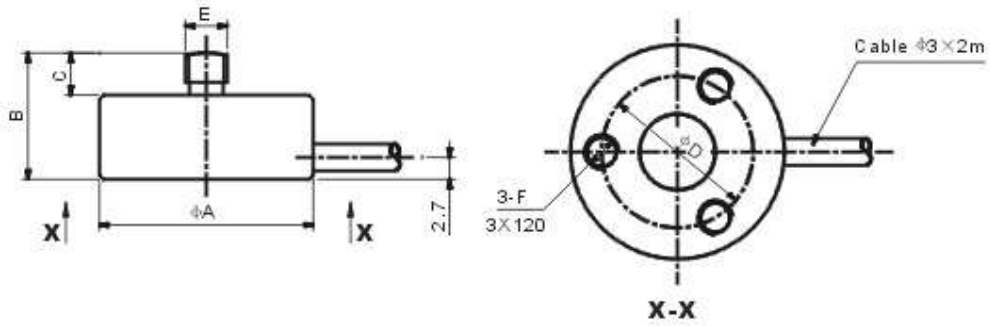
Subminiature Load Cell VZ247S 5 kg – 2 tonne

Special features

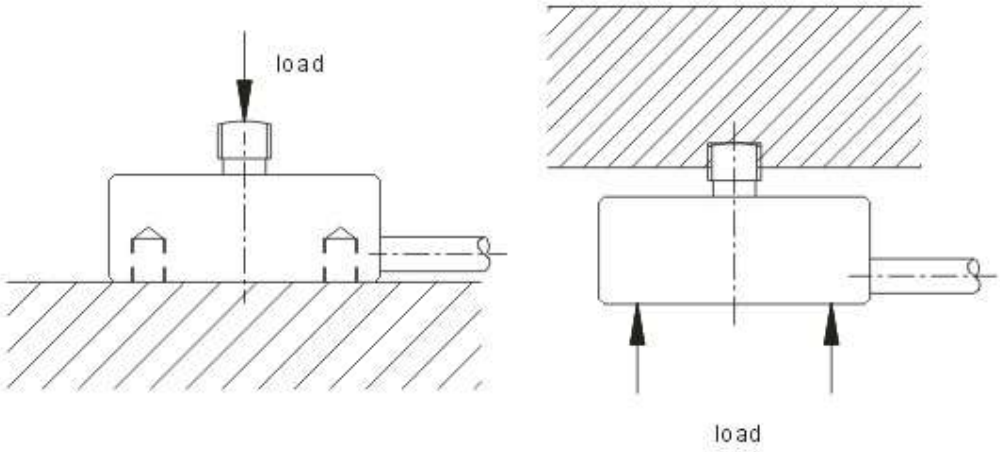
Miniature load cell, designed for use in limited space
Stainless steel (10; 20 kg aluminium)
Protection to IP66
Max. Capacities: 5 kg¡ to 2 tonne

Dimensions (in mm; 1mm = 0.03937 inches)



Max.Cap	A	B	C	D	E	F
1kg...200kg	20	11	4	15	M3	M3Depth4
500kg~2t	25.4	15	5	18	M5	M4Depth5

Application examples(in diagram form)



Vetek AB
Box 79, Industrivagen 3 Tel +46-176 208 920 www.vetek.net
760 40 Vaddo, Sweden Fax +46-176 208 929 e-mail info@vetek.se
Datasheet VZ247S Rev01.2007 Printed 2007-07-31

Type		VZ247S	
Accuracy class		0.5	
Maximal Capacity(Emax) Weight (G), approx. Sensitivity (Cn) Material	kg kg mV/V	10;20 0.04 1 ±20% Aluminium	50;100;200;500;1000;2000 0.08 1,5 ±20% Stainless steel 17-4PH
Zero balance Temperature effect on sensitivity (TKc) * Temperature effect on zero balance (TKo) Non-linearity (dlin) * Repeatability (drep) * Hysteresis error (dhy) * Creep (dDR)in 30 min. Input resistance (RLC) [Red(+)-white(-)] Output resistance (RO) [blue(+)-green(-)] Reference excitation voltage (Uref) Maximal excitation voltage Insulation resistance (Ris) Nominal temperature range Service temperature range Storage temperature range	mV/V % of Cn/k % of Cn/k % % % % ohm ohm V(DC/AC) V(DC/AC) G ohm ºC ºC ºC	<±0,5 <±0.02 <±0.02 <±0.5 <±0.3 <±0.5 <±0.5 350 ±20 350 ±3 0.5 - 6 12 >2 [50 VDC] -10 to + 40 -30 to + 70 -50 to + 85	
Safe load limit (EL) Breaking load (Ed)	% of Cn % of Cn	150 300	
Protection class (IP) acc. to IEC529		IP66	

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ELFA

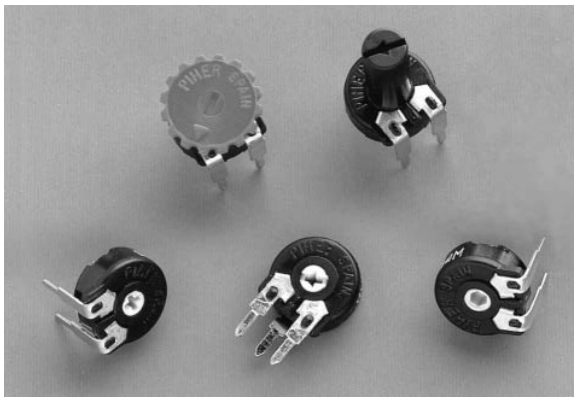
PRODUKTINFORMATION

Vi reserverar oss mot fel samt förbehåller oss rätten till ändringar utan föregående meddelande

ELFA artikelnr	
64-351-01	Trimpot PT10MV10 100ohm
64-351-19	Trimpot PT10MV10 220ohm
64-351-27	Trimpot PT10MV10 470ohm
64-351-35	Trimpot PT10MV10 1,0kohm
64-351-43	Trimpot PT10MV10 2,2kohm
64-351-50	Trimpot PT10MV10 4,7kohm
64-351-68	Trimpot PT10MV10 10kohm
64-351-76	Trimpot PT10MV10 22kohm
64-351-84	Trimpot PT10MV10 47kohm
64-351-92	Trimpot PT10MV10 100kohm
64-352-00	Trimpot PT10MV10 220kohm
64-352-18	Trimpot PT10MV10 470kohm
64-352-26	Trimpot PT10MV10 1,0Mohm
64-352-34	Trimpot PT10MV10 2,2Mohm
64-352-42	Trimpot PT10MV10 4,7Mohm
64-355-07	Trimpot PT10MH01 100ohm
64-355-15	Trimpot PT10MH01 220ohm
64-355-23	Trimpot PT10MH01 470ohm
64-355-31	Trimpot PT10MH01 1,0kohm
64-355-49	Trimpot PT10MH01 2,2kohm
64-355-56	Trimpot PT10MH01 4,7kohm
64-355-64	Trimpot PT10MH01 10kohm
64-355-72	Trimpot PT10MH01 22kohm
64-355-80	Trimpot PT10MH01 47kohm
64-355-98	Trimpot PT10MH01 100kohm
64-356-06	Trimpot PT10MH01 220kohm
64-356-14	Trimpot PT10MH01 470kohm
64-356-22	Trimpot PT10MH01 1,0Mohm
64-356-30	Trimpot PT10MH01 2,2Mohm
64-356-48	Trimpot PT10MH01 4,7Mohm
64-360-00	Trimpot PT10LV 100ohm
64-360-34	Trimpot PT10LV 250ohm
64-360-67	Trimpot PT10LV 470ohm
64-360-91	Trimpot PT10LV 1kohm
64-361-25	Trimpot PT10LV 2,2kohm
64-361-58	Trimpot PT10LV 4,7kohm
64-361-82	Trimpot PT10LV 10kohm
64-362-16	Trimpot PT10LV 22kohm
64-362-40	Trimpot PT10LV 47kohm
64-362-73	Trimpot PT10LV 100kohm
64-363-07	Trimpot PT10LV 220kohm
64-363-31	Trimpot PT10LV 470kohm
64-363-64	Trimpot PT10LV 1Mohm
64-363-98	Trimpot PT10LV 2,2Mohm
64-364-22	Trimpot PT10LV 4,7Mohm
64-365-05	Trimpot PT10LH 100ohm
64-365-39	Trimpot PT10LH 220ohm
64-365-62	Trimpot PT10LH 470ohm
64-365-96	Trimpot PT10LH 1kohm
64-366-20	Trimpot PT10LH 2,5kohm
64-366-53	Trimpot PT10LH 4,7kohm
64-366-87	Trimpot PT10LH 10kohm
64-367-11	Trimpot PT10LH 22kohm
64-367-45	Trimpot PT10LH 47kohm
64-367-78	Trimpot PT10LH 100kohm
64-368-02	Trimpot PT10LH 220kohm
64-368-36	Trimpot PT10LH 470kohm
64-368-69	Trimpot PT10LH 1Mohm
64-368-93	Trimpot PT10LH 2,2Mohm
64-369-27	Trimpot PT10LH 4,7Mohm
64-380-14	Tumhjul PT10 sexkant svart
64-380-22	Tumhjul PT10 sexkant röd
64-380-48	Tumhjul PT10 sexkant grön
64-380-55	Tumhjul PT10 sexkant blå
64-380-71	Tumhjul PT10 sexkant vit
64-380-89	Tumhjul PT10 sexkant gul
64-381-05	Axel PT10M svart L=10mm
64-381-13	Axel PT10M röd L=10mm
64-381-39	Axel PT10M grön L=10mm
64-381-47	Axel PT10M blå L=10mm
64-381-62	Axel PT10M vit L=10mm
64-381-70	Axel PT10M gul L=10mm

PIHER

PT-10 10 mm Carbon Potentiometer



FEATURES

- Carbon resistive element
- Dust proof enclosure
- Polyester substrate
- Also upon request:
  - Wiper positioned at 50% or fully clockwise.
  - Supplied in magazines for automatic insertion.
  - Long life model for low cost control potentiometer applications
  - Self extinguishable plastic UL 94V-0
  - Cut track option
  - Special tapers
  - Mechanical detents
  - Low & extra low torque versions

MECHANICAL SPECIFICATIONS

– Mechanical rotation angle:	235° ± 5°
– Electrical rotation angle:	220° ± 20°
– Torque:	0.4 to 2 Ncm. (0.6 to 2.7 in-oz)
– Stop torque:	> 5 Ncm. (>7 in-oz)

ELECTRICAL SPECIFICATIONS

- Range of values (*)
  100Ω ≤ Rn ≤ 5 M (Decad. 1.0 - 2.0 - 2.2 - 2.5 - 4.7 - 5.0)
- Tolerance (*): 100Ω ≤ Rn ≤ 1M Ω ------ ± 20%
  1MΩ < Rn ≤ 5M Ω ------ ± 30%
- Max. Voltage: 200 VDC (lin) 100 VDC (no lin)
- Nominal Power 50°C (122°F) (see power rating curve)
  0.15 W (lin) 0.07 W (no lin)
- Taper (*) (Log. & Alog. only Rn > 1K) Lin ; Log; Alog.
- Residual resistance: ≤ 5.10^{-3} Rn (2 Ω min.)
- Equivalent Noise Resistance: ≤ 3% Rn (3 Ω min.)
- Operating temperature**: -25°C + 70°C (-13°F + 158°F)

(*) Others upon request

** Up to 85°C depending on application

HOW TO ORDER

STANDARD

PT 10	L	H01	101	A	2020
Series: PT-10	Rotors: G L M K X W Y Z (See note 1)	Code / Mounting Method: H01 H2.5; H05 H5; H02 H2.5P; H10 H5P; V05 V5; V10 V; V11 VP; V13 VJ (See note 2)	Value: 101 = 100Ω; 504 = 500 K; 505 = 5 M (See note 3)	Taper: A = Lin. B = Log. C = Alog.	Tolerance: 2020 = ± 20%; 3030 = ± 30% (See note 4)

OPTIONAL EXTRAS

Life	Detent	Shaft/Thum.	Shaft/rotor colour	Torque
E= Long life (See note 5)	See PT's with detents data sheet	01 = Fig. 1; 02 = Fig. 2; ... 17 = Fig. 17	RO = Red; NE = Black; VE = Green; AM = Yellow; AZ = Blue; MA = Brown; GR = Grey; NA = Orange; CR = Cream (See note 8)	– = Standard; L= Low Torque; X = Extra Low Torque (See note 9)

Cut track	Magazine	Flammability	Wiper position
PCI = Initial; PCF = Final	T (See note 6)	I = Non flammable (See note 7)	PM = 50%; PF = Final

NOTES:

(1) "Z" adjustment only available on "H" versions
(2) Terminals styles: "P" & "J" are crimped terminals
(3) Value Example: Code: 10 1 → 100 Ω (10: First two digits of the value; 1: Numb of zeros)
(4) Non standard tolerance, upon request. Example: +7% -5% Code: 07 05 (07: negative tolerance; 05: positive tolerance)
(5) Life • Standard 500 cycles • Long life 10000 cycles
(6) Magazines: not available with the H10, V05 and V13 models, nor with adjustment types X, W, Y, Z.
(7) Non flammable: housing, rotor and shaft.
(8) Colour shaft/rotor: • Potentiometer without shaft: only rotor • Potentiometer with shaft: only shaft
Cream colour only available in standard plastic.
(9) Low Torque: 0.25 to 1 Ncm (per pot.)
Extra Low Torque: 0.1 to 0.4 Ncm (per pot.)
No detent option available for low and extra low torque models

NOTE: The information contained here in may be changed without prior notice.

HOW TO ORDER CUSTOM DRAWING

PT-10 LH 01 + DRAWING NUMBER (Max. 16 characters)

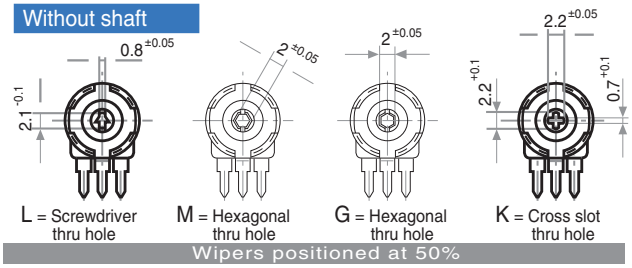
This way of ordering should be used for options which are not included in the "How to order" standard and optional extras.

STANDARD OPTIONS

Mechanical Life	500 cycles
Cut track	No
Detents	None
Packing	Bulk
Non flammable	No
Rotor colour	White
Shaft colour	Natural
Wiper position	Initial
Torque	Standard

ROTORS

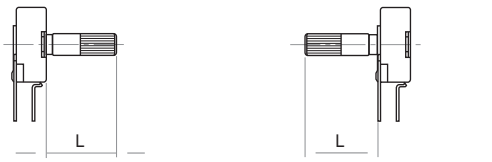
Without shaft



L = Screwdriver thru hole
M = Hexagonal thru hole
G = Hexagonal thru hole
K = Cross slot thru hole

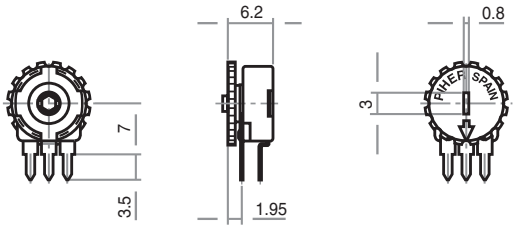
Wipers positioned at 50%

With shaft

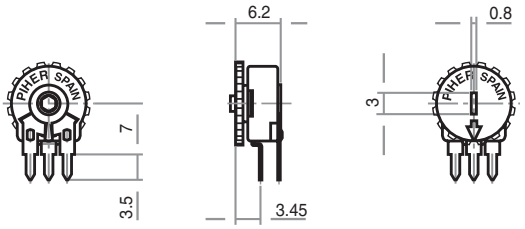


X = Adjustable from collector side
W = Adjustable from terminal side

With thumbwheel



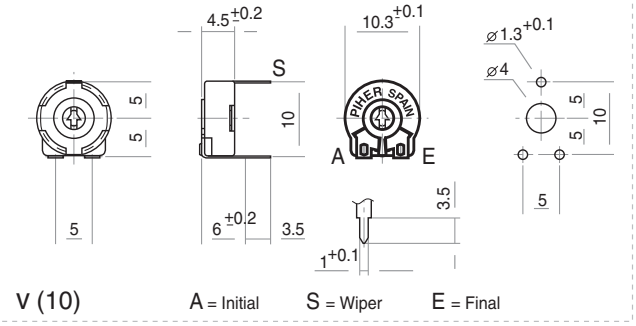
Y = Adjustable from terminal side



Z = Adjustable from collector side

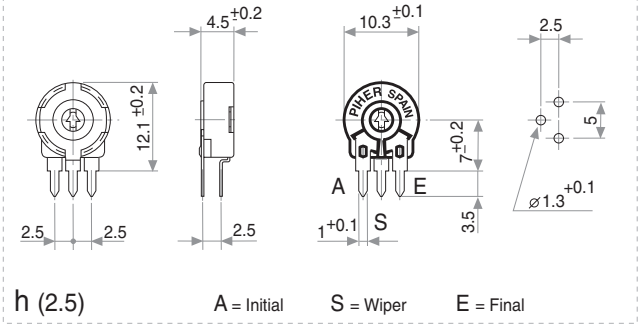
MOUNTING METHODS

v = horizontal mount – vertical adjust

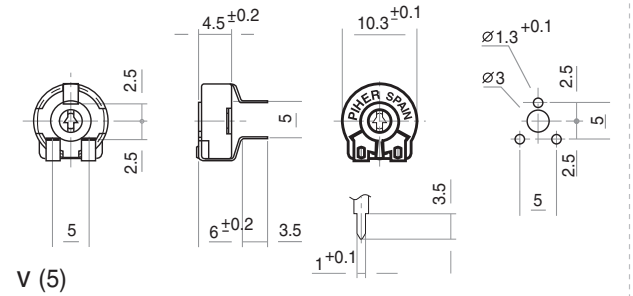


v (10) A = Initial S = Wiper E = Final

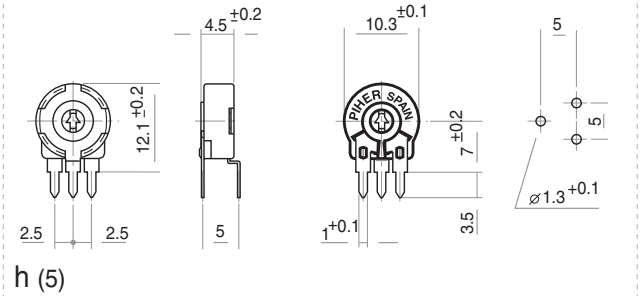
h = vertical mount – horizontal adjust



h (2.5) A = Initial S = Wiper E = Final



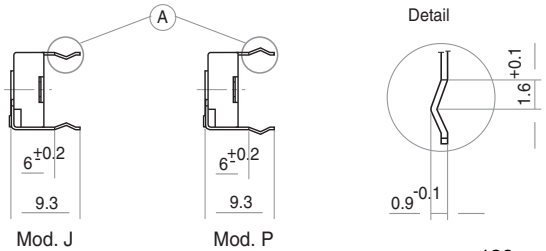
v (5)



h (5)

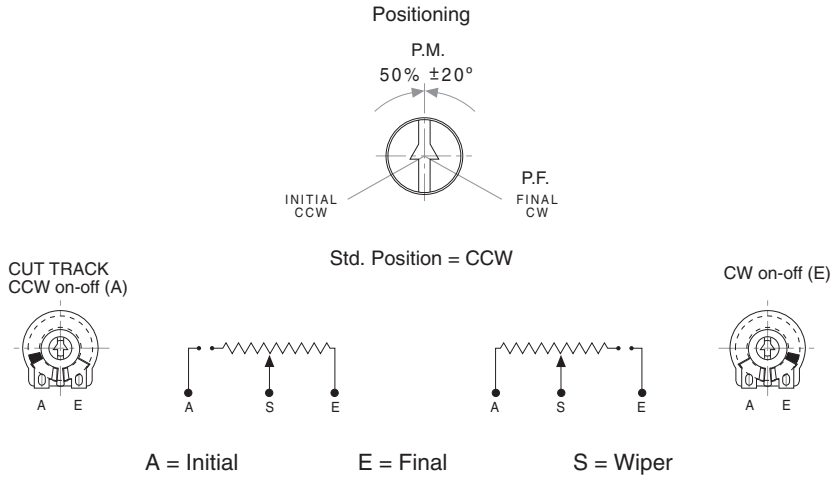
NOTE = Please note relative terminal positions when ordering non linear tapers.

Crimped terminals

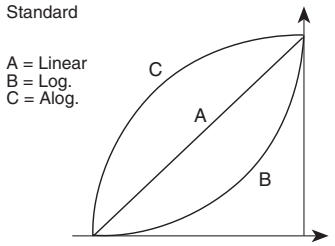


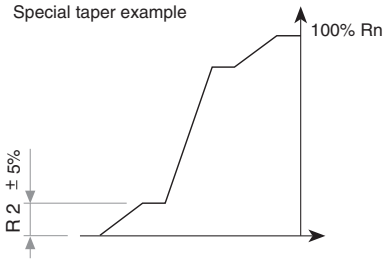
Mod. J Mod. P

OPTIONS

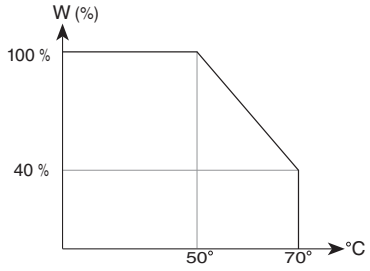


TAPERS





POWER RATING CURVE



NOTE = Please note relative terminal positions when ordering non linear tapers.

TESTS

TYPICAL VARIATIONS

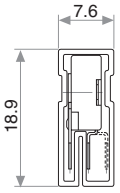
ELECTRICAL LIFE	1.000 h. @ 50°C; 0.15 W	±5 %
MECHANICAL LIFE (CYCLES)	500 @ 10 CPM ...15 CPM	±3 % (Rn < 1 MΩ)
TEMPERATURE COEFFICIENT	–25°C; +70°C	±300 ppm (Rn <100 K)
THERMAL CYCLING	16 h. @ 85°C; 2h. @ –25°C	±2.5 %
DAMP HEAT	500 h. @ 40°C @ 95% HR	±5 %
VIBRATION	2 h. @ 20 g. @ 10 Hz. ... 50 Hz.	±2 %

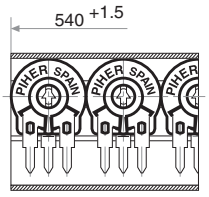
NOTE: Out of range values may not comply these results.

PACKAGING

BOXES

Model	Units
Without shaft	500 (40 x 85 x 185 mm.)
With thumbwheel	400 (40 x 85 x 185 mm.)
With shaft	200 (40 x 85 x 185 mm.)



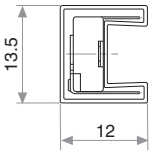


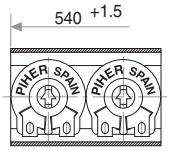
Magazines for PT-10 h 2.5; h 5

Also crimped term. h 2.5 P

AUTOMATIC INSERTION

Magazines	Units per magazine
PT-10H & PT-10V	50 Pieces





Magazines for PT-10 V

Also crimped term. VP

SHAFTS

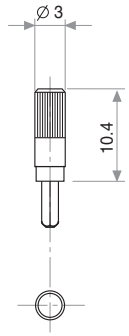


Fig. 1 / Ref. 5016

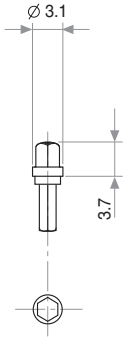


Fig. 2 / Ref. 5053

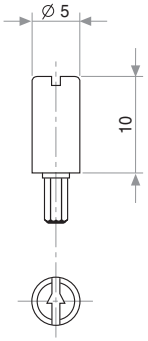


Fig. 3 / Ref. 5012

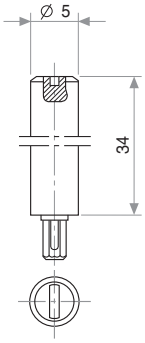


Fig. 4 / Ref. 6053

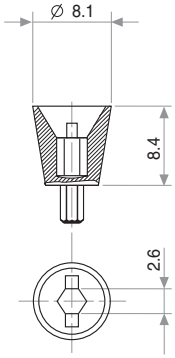


Fig. 6 / Ref. 5035

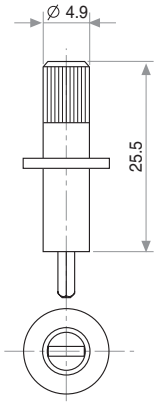


Fig. 7 / Ref. 5115

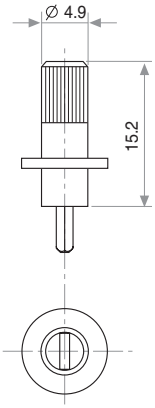


Fig. 8 / Ref. 5116

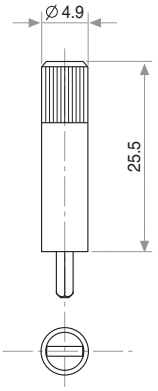


Fig. 9 / Ref. 5119

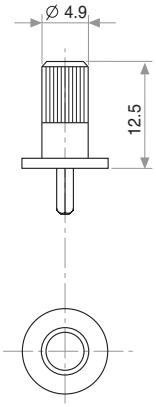


Fig. 10 / Ref. 5120

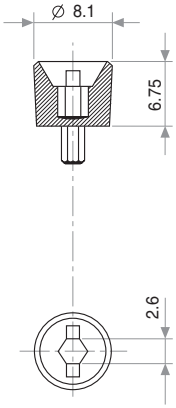


Fig. 11 / Ref. 5027

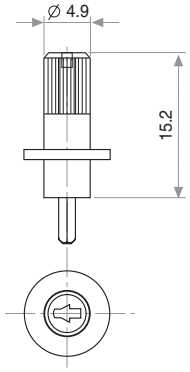


Fig. 12 / Ref. 6052

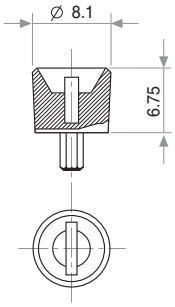


Fig. 13 / Ref. 5121

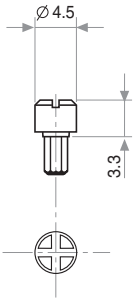


Fig. 14 / Ref. 5055

2- GANG Plastic Knob/ Plastic Shaft*

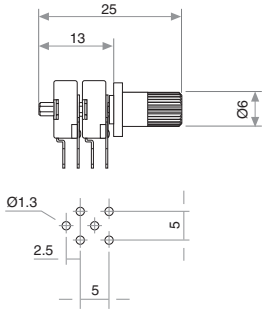


Fig. 18 / Ref. 6064

* Delivered unassembled
(For assembled contact your nearest PIHER supplier)

THUMBWHEELS

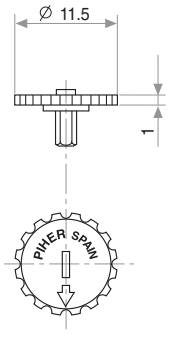


Fig. 5 / Ref. 5034

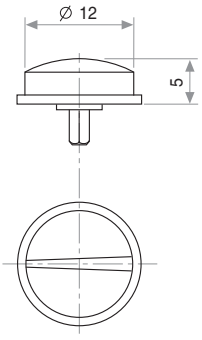


Fig. 15 / Ref. 6008

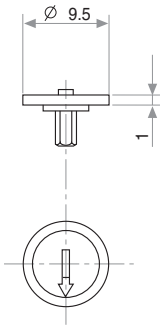


Fig. 16 / Ref. 5039

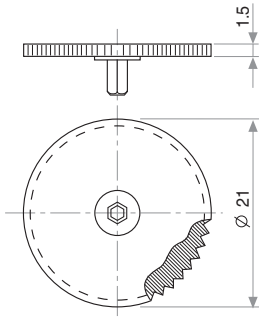


Fig. 17 / Ref. 5062

OTHER COMPONENTS & SENSORS

MedTech – MF2003
2008-05-13

ZEICHNUNG GESCHÜTZT DURCH
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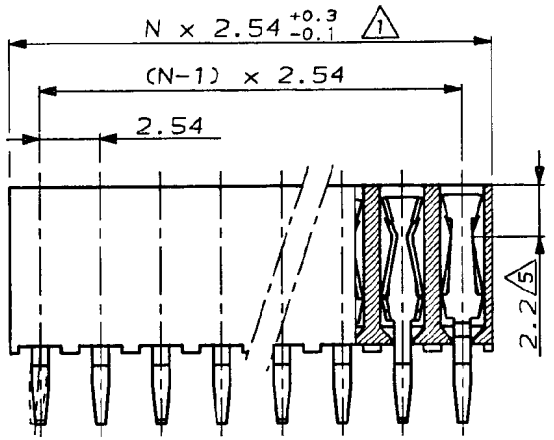
ALLE RECHTE VORBEHALTEN

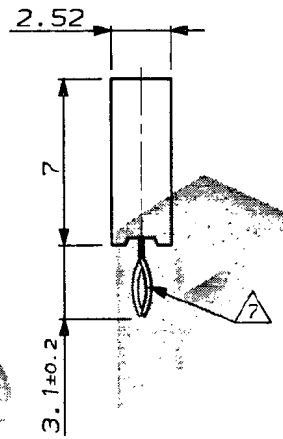
REV.	ÄNDERUNG	DATUM	NAME
1	MASS 2.54 $^{+0.3}_{-0.1}$ WAR 2.54 ,2.2 WAR 2.5		
	MASS 3.0±0.2 WAR 3.0 HINZU ALLG. TOLERANZ ±0.1	02.11.88	AUGUSTINIAK
2	ZEICHNUNG IN EUROPEAN PROJECTION GEÄNDERT	30.11.90	A.HO
3	LÖTLÄNGE VON 3 IN 3.1 GEÄNDERT	12.03.92	A.HO

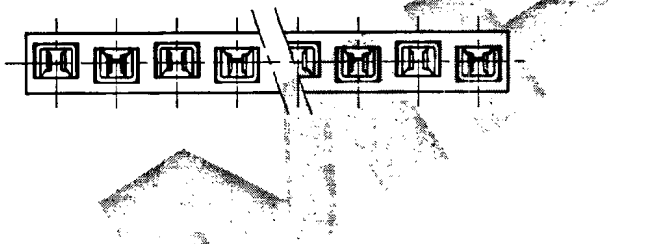
DO NOT SCALE
DIMENSIONS IN mm

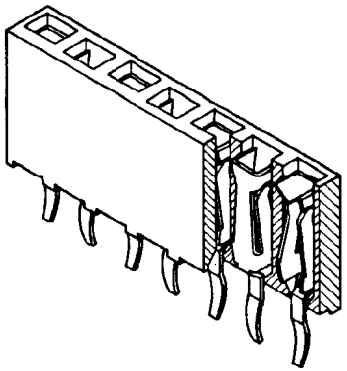
METRIC

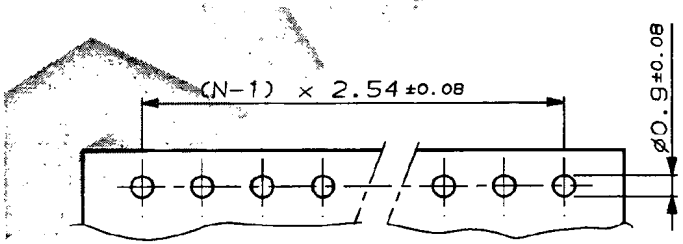
EUROPEAN PROJECTION











P.C.-BOARD HOLE-PATTERN

NOTES:

1. TO DETERMINE DIMENSIONS TAKE N = NR. OF POS.
   FOR EXAMPLE: 10 POS.: N x 2,54 = 25,4 mm.
   FOR ORDERNR. USE BASIC NR. + NR. OF POS.
   FOR EXAMPLE: 2 POS.= 215 297-2 (SHORTEST VERSION)
   36 POS.= 3-215 297-6 (LONGEST VERSION)
2. HOUSING MATERIAL: GREEN GLASSFILLED POLYESTER, UL 94V-0
   CONTACT MATERIAL: PHOSPHORBRONZE.
3. PLATING: UNDERCOATING: 1,3µm Ni.
   AT CONT.PLACE: 0,8µm Au.
   AT SOLDER-TYNES: 2,5µm Sn.Pb.
4. MATES WITH 0,63 SQUARE/ROUND MODU POSTS.
5. CONTACT-POINT.
6. RECOMMENDED P.C.BOARD-THICKNESS: 1,6.
7. RETENTION FEATURE.

	SEE NOTES	SEE NOTES	SEE NOTES
	FINISH	MATERIAL	PARTNUMBER

CUSTOMER DRAWING

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AMP-HOLLAND B.V.
's-Hertogenbosch, The Netherlands.

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DR. R.VISSER	DATE 08.05.87	WIRE RANGE -	NAME HV 100 VERTICAL CONNECTOR	REV. DATE D M Y
CHK. W.SIMONS	DATE	INSUL.RANGE -	SINGLE ROW, 7,0mm HEIGHT, TOP ENTRY, GOLD, MAX. 36 POSITIONS.	30 11 90
APP. L.v.SOEST	DATE	SIZE A3	SHEET 1 OF 1	DWG. No. 215 297

REV.LTR. 3

NICHT TOLERIERTE MASSE ± 0.1 ± -

MASSTAB 5:1

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Lead Free Conversion in Process - Refer to Specification 230-700 at www.tycoelectronics.com/leadfree

ZEICHNUNG GESCHÜTZT DURCH
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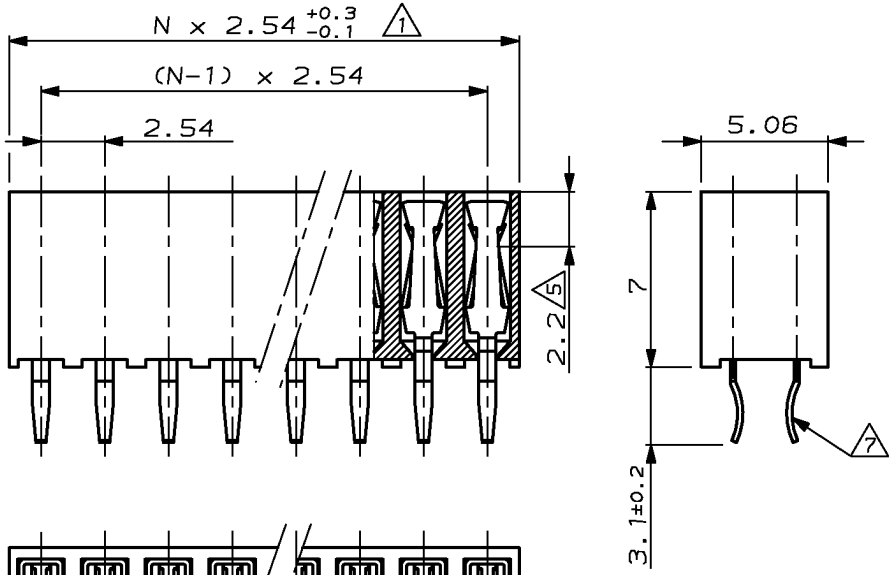
ALLE RECHTE VORBEHALTEN

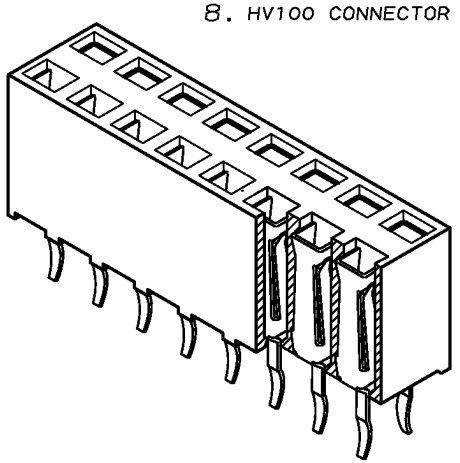
REV.	ÄNDERUNG	DATUM	NAME
1	MASS 2.54 +0.3 −0.1 WAR 2.54		
	MASS 3.0±0.2 WAR 3.0 HINZU ALLG. TOLERANZ ±0.1	02.11.88	AUGUSTINIAK
2	ZEICHNUNG IN EUROPEAN PROJECTION GEÄNDERT	04.12.90	A.HO
3	LÖTLÄNGE VON 3 IN 3.1 GEÄNDERT	12.03.92	A.HO
C	VERPACKUNGSANGABE HINZU	15.01.96	F.RDT

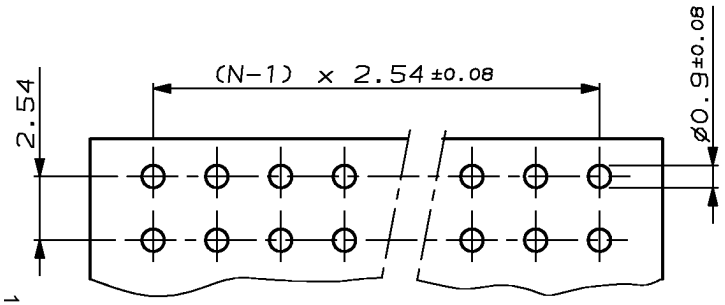
DO NOT SCALE
DIMENSIONS IN mm

METRIC

EUROPEAN PROJECTION







P.C.-BOARD HOLE-PATTERN

NOTES:

1. TO DETERMINE DIMENSIONS TAKE 2xN = NR. OF POS.
   FOR EXAMPLE: 2x10 POS.: N x 2,54 = 25,4 mm.
   FOR ORDERNR. USE BASIC NR. + NR. OF POS.
   FOR EXAMPLE: 2x2 POS.= 215 307-2 (SHORTEST VERSION)
   2x36 POS.= 3-215 307-6 (LONGEST VERSION)
2. HOUSING MATERIAL: GREEN GLASSFILLED POLYESTER, UL 94V-0
   CONTACT MATERIAL: PHOSPHORBRONZE.
3. PLATING: UNDERCOATING: 1,3µm Ni.
   AT CONT.PLACE: 0,8µm Au.
   AT SOLDER-TYNES: 2,5µm Sn.Pb.
4. MATES WITH 0,63 SQUARE/ROUND MODU POSTS.
5. CONTACT-POINT.
6. RECOMMENDED P.C.BOARD-THICKNESS: 1,6.
7. RETENTION FEATURE.
8. HV100 CONNECTOR PACKED IN ANTISTATIC BLISTER

VERWENDET FÜR E 91-52 572	SEE NOTES FINISH	SEE NOTES MATERIAL	SEE NOTES PARTNUMBER

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DR. R.VISSER	DATE 08.05.87	WIRE RANGE -	NAME HV 100 VERTICAL CONNECTOR	REV.DATE D M Y 15 01 96
CHK. W.SIMONS	DATE	INSUL.RANGE -	DUAL ROW, 7,0mm HEIGHT, TOP ENTRY, GOLD, MAX. 2x36 POSITIONS.	
APP. L.v.SOEST	DATE	SIZE A3	SHEET 1 OF 1	DWG. No. 215307 REV.LTR. C

NICHT TOLERIERTE MASSE ± 0.1mm ± −
MASSTAB 5:1

129

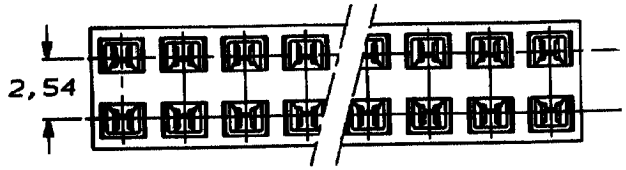
8 7 6 5 4 3 2 1

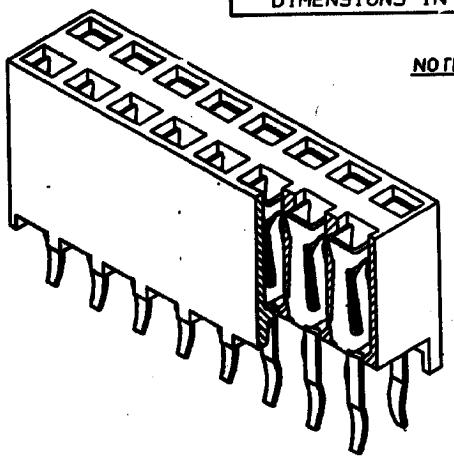
REV.	BESCHRIJVING	DATUM	NAME
1	MASS 2.54 ± MSS 2.54	09.11.88	AUGUSTINIAK

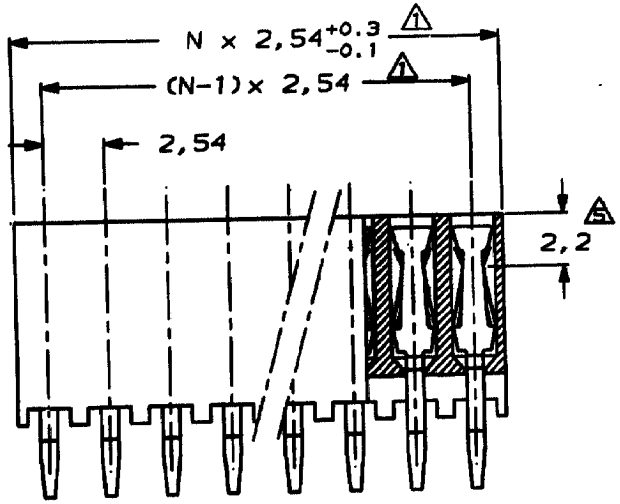
DO NOT SCALE
DIMENSIONS IN mm

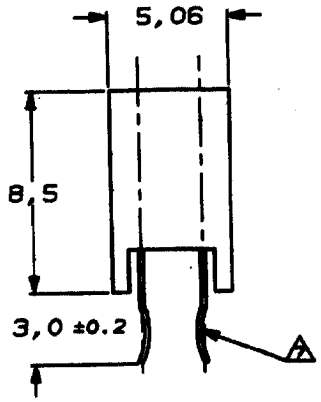
METRIC

THIRD ANGLE PROJECTION









NOTES:

1. TO DETERMINE DIMENSIONS TAKE 2xN = NR. OF POS.
   FOR EXAMPLE: 2x10 POS., N x 2,54 = 25,4 mm.
   FOR ORDERNR. USE BASIC NR. + NR. OF POS.
   FOR EXAMPLE: 2x2 POS.= 215309-2 (SHORTEST VERSION)
   2x36 POS.= 3-215309-6 (LONGEST VERSION)
2. HOUSING MATERIAL: GREEN GLASSFILLED POLYESTER, UL 94V-0
   CONTACT MATERIAL: PHOSPHORBRONZE.
3. PLATING: UNDERCOATING: 1,3µm Ni.
   AT CONT.PLACE: 0,8µm Au.
   AT SOLDER-TYNES: 2,5µm Sn.Pb.
4. MATES WITH 0,63 SQUARE/ROUND MODU POSTS.
5. CONTACT-POINT.
6. RECOMMENDED P.C.BOARD-THICKNESS: 1,6.
7. HIGH TEMPERATURE SEALANT.
8. RETENTION FEATURE.

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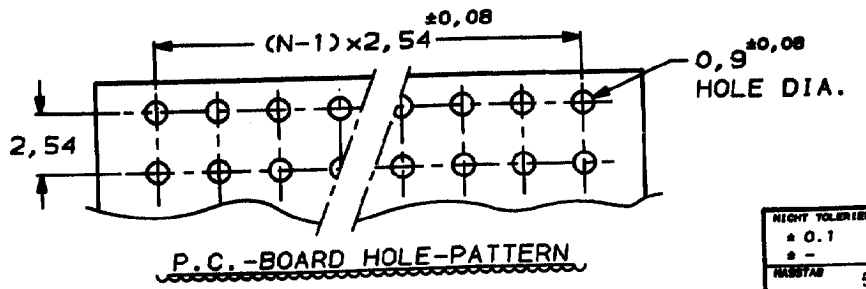
WILL NOT BE UP-DATED



	SEE NOTES	SEE NOTES	SEE NOTES
	FINISH	MATERIAL	PARTNUMBER

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AMP-HOLLAND B.V.
's-Hertogenbosch, The Netherlands.

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DR. L.V.D.HEYDEN	DATE 09.07.86	WIRE RANGE -	NAME HV-100 VERTICAL CONNECTOR
CHK. W.SIMONS	DATE	INSUL.RANGE -	DUAL ROW, 8,5mm HEIGHT, TOP ENTRY, GOLD, MAX. 2x36 POSITIONS.
APP. L.v.SOEST	DATE	SIZE A3	SHEET 1 OF 1

DWG. No. C-215309

REV.DATE D M Y: 02 11 88

REV.LTR: 1

NICHT TOLERIERTE MASSE ± 0.1 ± -

MASSTAB 5:1

Lead Free Conversion in Process - Refer to Specification 230-700 at www.tycoelectronics.com/leadfree

N-15 15mm Carbon Position Sensor/ Potentiometer

FEATURES

Conceived and designed for customisation
SMD or Through-hole Mount
Endless Rotation (360º)
Wide Electrical Angle (340º ± 10º)
Extended Mechanical Life (100k cycles)
Working Temperature Range (-40ºC to +120ºC)
Low Profile (4.4 mm)
Linearity ± 3% (standard)
Embossed Tape or Bulk packaging
Reflow Soldering capability
Shaft insertable from both sides
Polarised "T" rotor (European Home Appliance standard)
All PT/ PTC 15 shafts compatible

STANDARD SPECIFICATIONS

Resistance values(*):	5k, 10k, 100k
Tolerance:	± 30%
Nominal Power:	0.15 W @ 50ºC
Linearity (absolute):	± 3%
Taper:	Linear
Mechanical Life:	100,000 cycles
Temperature Range:	-40ºC to +120ºC
Mechanical Angle:	360º
Electrical Angle:	340º ± 10º
Rotational Torque:	≤ 20 mN.m
Max. Voltage:	250 VDC

(*) Others upon request

TYPICAL APPLICATIONS

The N15 series offers an SMD and Through Hole mount solution for the majority of Position/Rotary Sensor and multi-purpose Control applications such as:

- Automotive HVAC, Seat, Rear-view mirror actuator feedback sensors and HVAC Controls
-Temperature Control for Boilers, Wall Heaters, Showers, Radiators, Conventional and Microwave Ovens, Freezers...
- Timer & Function/Programme Select for Washing Machines, Dishwashers and all White Goods in general.
- Size and Position detectors

HOW TO ORDER

N-15	T	S	103	A	3030
Series	Rotors	Mounting Method	Value	Taper	Tolerance
N-15	T	V =Through Hole S = SMD	502 = 5 K 103 = 10 K 104 = 100 K	A = Lin.	3030 = ± 30%
(See note 1)				(See note 2)	(See note 3)

NOTES:

(1) A wide variety of custom substrates available
(2) Availability of a wide range of customised tapers and step curves
(3) Optional precision laser-trimmed voltage divider calibration

Shafts are not available mounted to the potentiometer and should be ordered separately

NOTE: The information contained here should be used for reference purposes only.

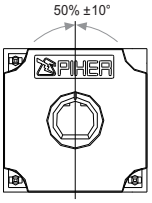
HOW TO ORDER CUSTOM DRAWING

N-15 T S + DRAWING NUMBER (Max. 16 digits)

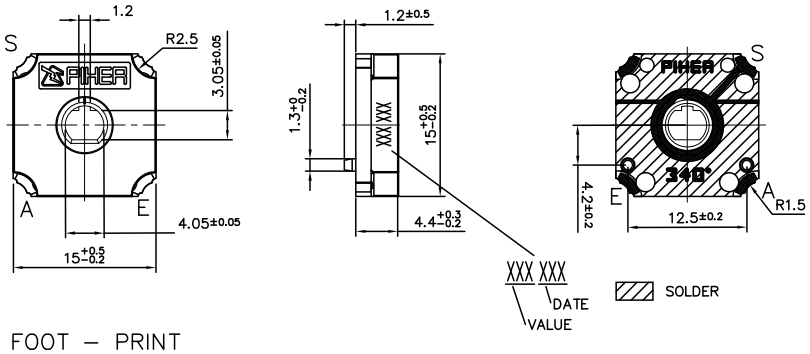
This way of ordering should be used for options which are not included in the "How to order" standard and optional extras.

STANDARD WIPER POSITION

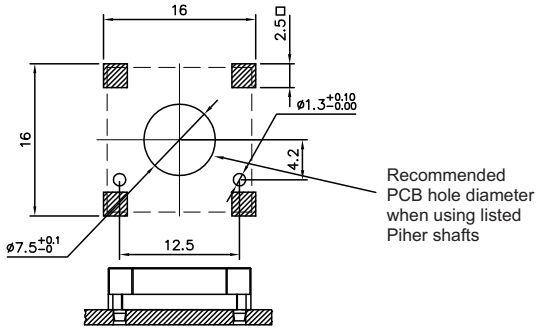
Wiper positioned at 50 % of the electrical angle.

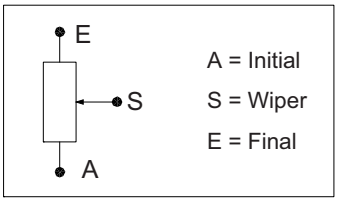


SMD MOUNT

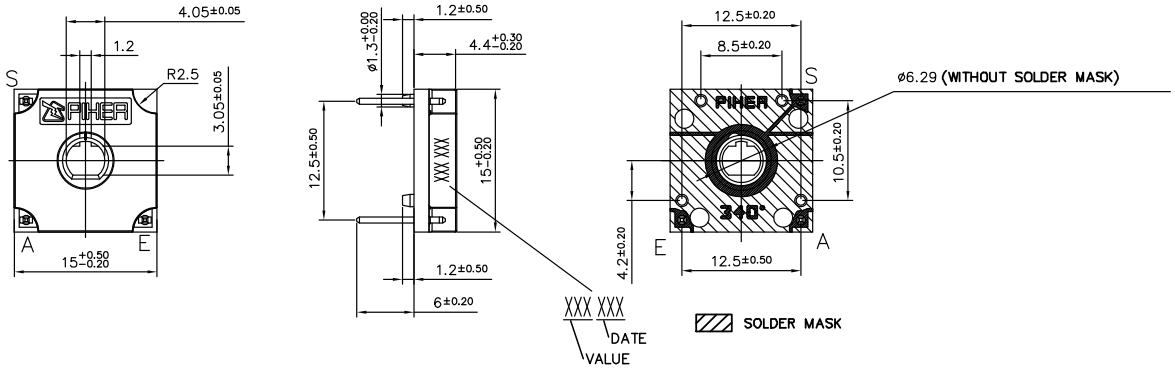


FOOT – PRINT

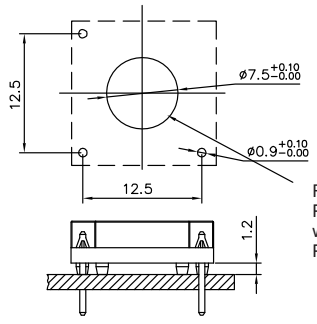




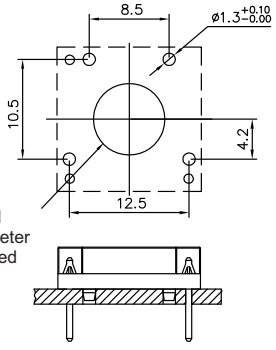
THROUGH HOLE MOUNT



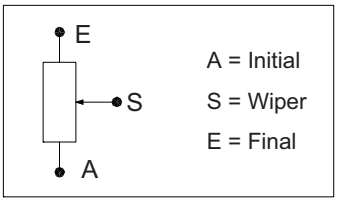
PCB HOLE LAYOUT 1



PCB HOLE LAYOUT 2



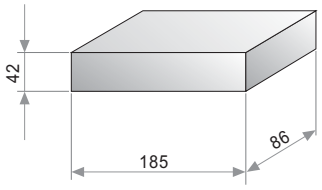
Recommended
PCB hole diameter
when using listed
Piher shafts



TESTS	TYPICAL VARIATIONS	
ELECTRICAL LIFE	1.000 h. @ 50°C; 0.15 W	±40 %
MECHANICAL LIFE (CYCLES)	100,000 @ 20 CPM	±40 % (Rn < 100 K)
TEMPERATURE COEFFICIENT	–40°C to +120°C	±300 ppm (Rn <100 K)
THERMAL CYCLING	10h. @ 120°C; 10h. @ -40°C	±40 %
DAMP HEAT	500 h. @ 40°C @ 95% HR	±40 %

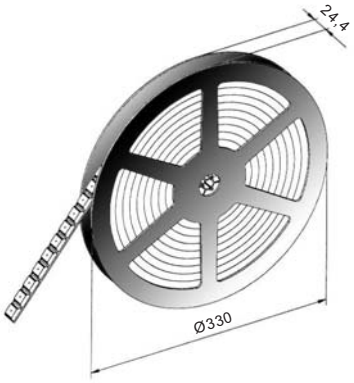
NOTE : Out of range values may not comply these results.

PACKAGING



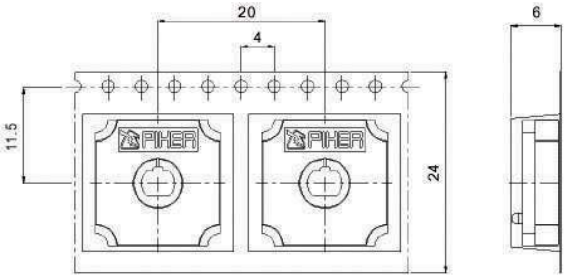
BULK

200 Units per box.
Through hole version only

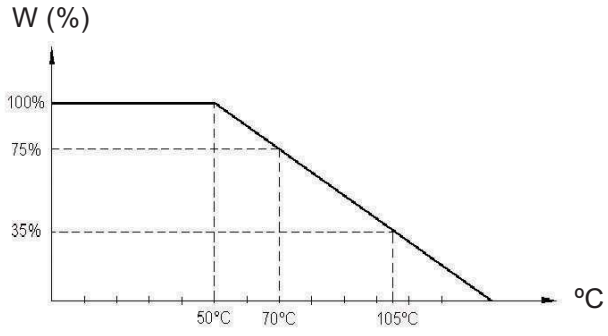


EMBOSSED TAPE

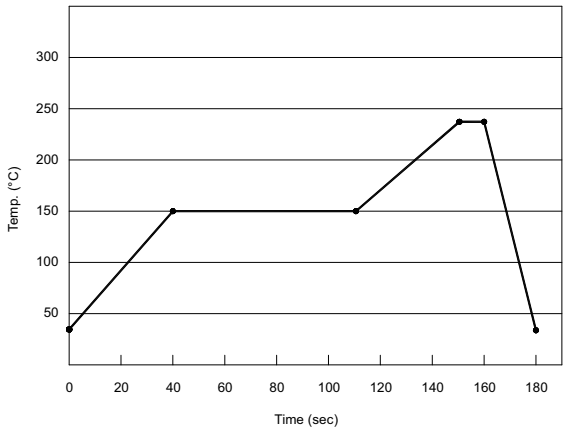
500 Units per Reel
SMD version only



POWER RATING CURVE



RECOMMENDED REFLOW PROFILE



Flow soldering (applicable for SMD type only):

Solder temperature:	max. 240ºC
Soldering time:	10 ±1 sec.
Preheating Temperature:	max. 150ºC
Heating time:	max. 2 min.

Hollow model shafts

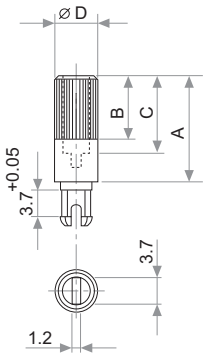


FIG.	A	B	C	D	Ref.
1	12	9	8	6	5272
2	19	9	15	6	5214
5	9.5	6.5	5.5	6	5208
9	35	9	15	6	5216
10	37.8	9	33.8	6	5218
11	35	25	15	6	5209
13	7.8	4.8	3.8	6	5265

Solid model shafts

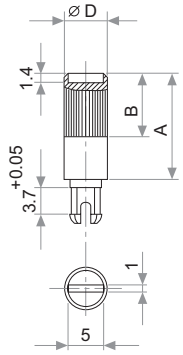


FIG.	A	B	D	Ref.
6	15	9	6	5219
7	16.8	9	6	5220
8	25.3	9	6	5207
12	46	5	6	5227

Slot (1 x 1.4) perpendicular to wiper position. Fig. 12 slot is on line with wiper position.

A = Length (FRS); B=Knurling length; C=Hollow depth; D=Shaft diameter; FRS=From rotor surface

Other shafts

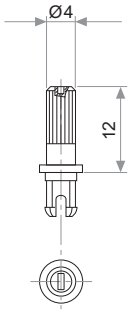


Fig. 3 / Ref. 5372

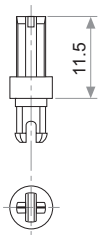


Fig. 14 / Ref. 5248

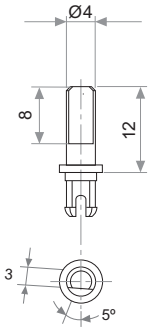


Fig. 15 / Ref. 5217

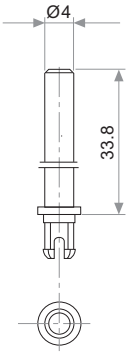


Fig. 16 / Ref. 5262*

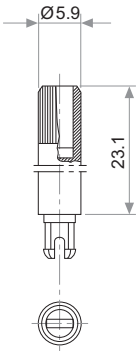


Fig. 17 / Ref. 5210

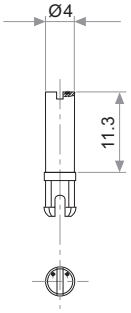


Fig. 18 / Ref. 5271

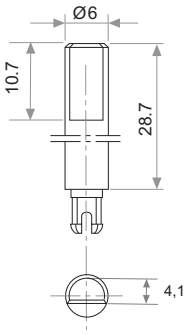


Fig. 19 / Ref. 6032*

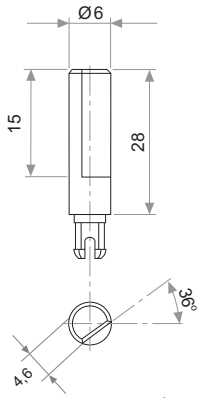


Fig. 20 / Ref. 5369*

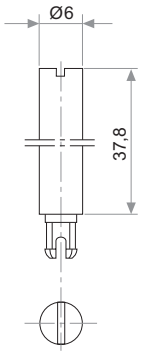


Fig. 21 / Ref. 6031*

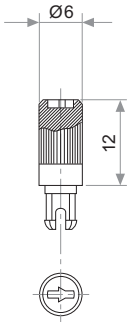


Fig. 22 / Ref. 6029

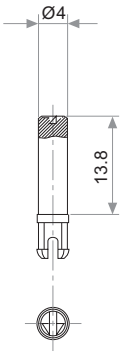


Fig. 23 / Ref. 6022

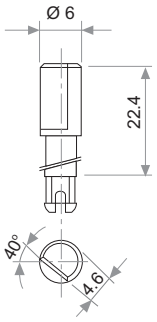


Fig. 24 / Ref. 6058

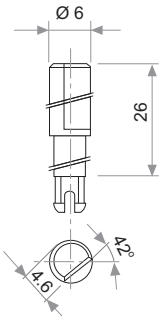


Fig. 25 / Ref. 6059

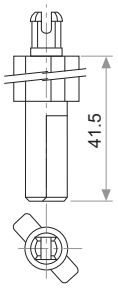


Fig. 27 / Ref. 5268*

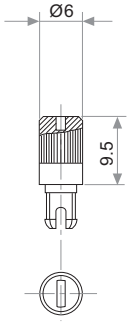


Fig. 28 / Ref. 6055

* Not available in self extinguishable plastic

2002-12-10

ELFA

PRODUKTINFORMATION

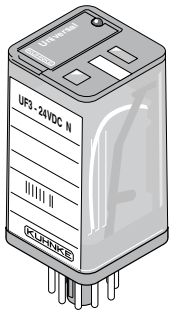
Vi reserverar oss mot fel samt förbehåller oss rätten till ändringar utan föregående meddelande

ELFA artikelnr

37-317-00 Relä UF3 24 VDC
37-318-09 Relä UF3 48 VDC
37-323-02 Relä UF3 24 VAC
37-323-28 Relä UF3 110 VAC
37-326-09 Relä UF3 230 VAC

Relay Universal UF2/UF3

- Standard type /
- Twin contacts for high contact making reliability
- With LED and protection diode on request



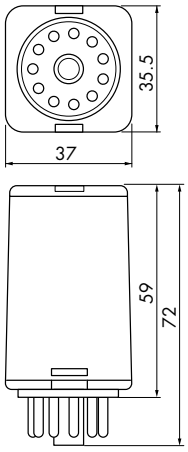
Order Code

Order code	U	F	3		–	24 V	DC	N	
Type of relay	U								
Model									
F Plug in type for socket, international 8-pole socket or 11pole socket resp.		F							
Contact arrangement									
2 C/O			2						
3 C/O			3						
Contact material, type of contact									
- Single contact AgNi (no code letter)				-					
B Single contact AgNi gold-plated				B					
F Twin contacts AgNi				F					
G Twin contacts AgNi gold-plated				G					
Nominal operation coil voltage (see coil data)									
24 V						24 V			
Coil current type									
DC Direct current							DC		
AC Alternating current 50 / 60 Hz							AC		
Version									
N With position indicator, with manual override, without override lever								N	
1 With position indicator, with manual override, with override lever								1	
Extensions									
- None (no code letter)									-
F Protection diode (on request)									F
L Luminous indicator (on request)									L

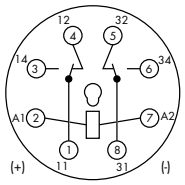
Contact Data

	UF2 / UF3			
Contact arrangement	2 or 3 C/O			
Type of contact	Single contact		Twin contact	
Contact material	AgNi	AgNi gold-plated	AgNi	AgNi gold-plated
Nominal contact current	10 A		4 A	
Inrush current	≤ 20 A		≤ 10 A	
Nominal contact voltage	250 VAC / DC		250 VAC	
Max. switching capacity (resistive)	3000 VA		1000 VA	
Min. switching capacity	50 mA / 20 VDC	1 mA /100 mVDC	20 mA / 10 VDC	1 mA /100 mVDC

Dimensions, Connection Diagram(s)

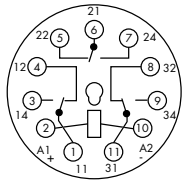


UF2 / UF3



Viewed on connector pins

UF2



Viewed on connector pins

UF3

General Data

	UF2 / UF3		
Pull-in-time	approx.12 ms		
Drop-out time	approx.10 ms		
Bounce time	approx. 5 ms		
Mechanical service life	> 20 x 10^6 switching cycles		
Test voltage			
Coil - contact	2500 VAC		
(C/O) - (C/O)	2500 VAC		
Contact - contact	1500 VAC		
Insulation group VDE 0110b/2.79	C250, B380		
Ambient temperature	-25 °C to +60 °C DC -25 °C to +40 °C AC		
Vibration resistance (30 - 100 Hz)	> 4 g		
Weight	approx. 90 g		
Operating range	DC Class 1 (0.8 – 1.1 U_N)	AC 50 Hz Class 1 (0.8 – 1.1 U_N)	AC 60 Hz Class 2 (0.85 – 1.1 U_N)
Pull-in after coil excitation with U_N at T_U	20 °C	20 °C	20 °C
Drop-out	> 0.05 U_N	> 0.15 U_N	> 0.15 U_N

Coil Data

Coil voltage DC	UF2 / UF3 Nom. operation coil power approx. 1.2 W Inrush current approx. 0.6 W		Coil voltage AC	UF2/UF3 Nom. operation coil power approx. 2.2 / 2.0 VA Inrush current approx. 1.5 x Nominal current		
Nominal voltage (V)	Nominal resistance (Ω)	Nominal current (mA)	Nominal voltage (V)	Nominal resistance (Ω)	Nominal current 50 Hz (mA)	Nominal current 60 Hz (mA)
12	96	125	24	74	107	91
24	384	63	60	474	43	36
60	2400	25	115	1710	23	19
110	7660	14	230	7500	17	10
220	30630	7.2				

Electrical Service Life

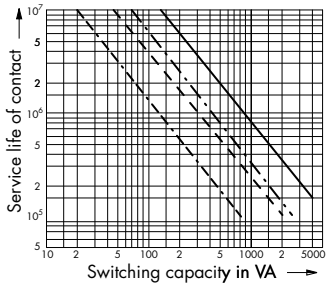
Electrical Service Life AC

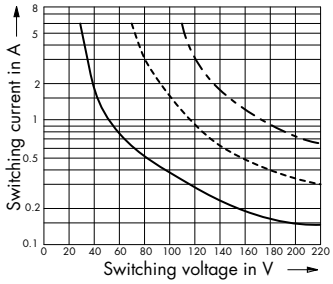
90 % operating

——— resistive load Single contacts
- - - - - inductive load Single contacts
— - — resistive load Twin contacts
— — — inductive load Twin contacts
cos φ = 0.4 ... 0.7

Switching capacity DC

Below limiting characteristic: service life of contacts
1 x 10^6 switching cycles (90 % operating)
resistive load
——— 1 contact
- - - - - 2 contacts in series
— - — 3 contacts in series





Universal Standard Types in Stock

available from stock in packets of 10 pcs each

DC			AC		
UF2-12VDC1	UF3-12VDC1	UF2G-24VDC1	UF2-24VAC1	UF3-12VAC1	UF3B-230VACN
UF2-24VDC1	UF3-12VDCN	UF3B-24VDC1	UF2-24VAC1L	UF3-24VAC1	UF3F-24VACN
UF2-24VDC1FL	UF3-24VDC1	UF3B-24VDC1FL	UF2-24VACN	UF3-24VAC1L	UF3F-230VAC1
UF2-24VDCN	UF3-24VDC1FL	UF3B-24VDC1L	UF2-110VAC1	UF3-24VACN	UF3F-230VACN
UF2-110VDCN	UF3-24VDC1L	UF3B-24VDCN	UF2-120VAC1	UF3-48VAC1	UF3G-110VAC1
	UF3-24VDCN	UF3F-24VDC1	UF2-230VAC1	UF3-110VAC1	UF3G-230VAC1
	UF3-24VDCNF	UF3F-24VDCN	UF2-230VAC1L	UF3-110VACN	UF3G-230VACN
	UF3-24VDCNFL	UF3F-24VDCNF	UF2-230VACN	UF3-115VAC1L	
	UF3-24VDCNL	UF3F-60VDCN		UF3-120VAC1	
	UF3-48VDC1	UF3F-110VDCN		UF3-230VAC1	
	UF3-48VDCN	UF3G-24VDC1		UF3-230VAC1L	
	UF3-60VDCN	UF3G-24VDC1FL		UF3-230VACN	
	UF3-110VDC1	UF3G-24VDCN		UF3-230VACNL	
	UF3-110VDC1FL	UF3G-24VDCNL			
	UF3-110VDCN	UF3G-60VDCN			
	UF3-125VDCN	UF3G-110VDCN			
	UF3-220VDC1				
	UF3-220VDCN				

Order Specifications for Accessories UF

	UF2	UF3
Socket for		
Screw connection with quick-action fastening / retaining clip	Z392 / Z434 Z395	Z345 / Z441 Z393 / Z434 Z396
Screw connection with quick-action fastening and protection diode		Z345.12 / Z441
Screw connection with quick-action fastening and RC combination		Z345.32 / Z441
Modules for socket Z396 / Z395		
Protection diode for 6 - 220 VDC	Z396.50	Z396.50
Protection / luminous diode for 24 VDC	Z396.52	Z396.52
RC combination for 110 / 230 VAC	Z396.53	Z396.53
Protection module with varistor for 24 VAC	Z396.54	Z396.54
Protection module with varistor for 230 VAC	Z396.55	Z396.55
Luminous indicator 230 VAC	Z396.58	Z396.58
Multi-function time module	Z396.64	Z396.64
Retaining clip	Z441 / Z434	Z441 / Z434

V4 Type Sub Miniature Microswitch

Features

- **Rating 5A switching S.P.D.T. (10A to order)**
- **Long life coil spring mechanism**
- **PC, 90˚pc or solder terminals standard**
- **2.8mm quick connect to order**
- **Button, lever or roller actuators**
- **UL/CSA approval pending**
- **Anti Solder Wicking**
- **High Quality**
- **Competitive pricing**

Specification

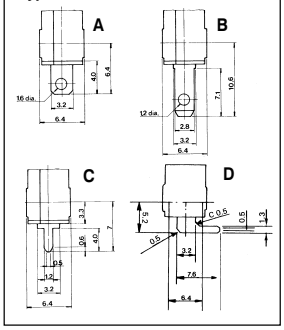
Rating:	5A 250V AC (10A to order)
Contact resistance:	100mΩ max
Insulation resistance:	100MΩ min/1.5kVac
Life mechanical:	$3x10^6$ operations min
Life electrical:	$1x10^6$ operations min
Temperature range:	-20˚C to +70˚C
Materials body:	PBT
Materials button:	PA 66
Materials actuators:	Stainless steel
Contact:	Silver
Terminals:	Silver plated brass
PCB mounting hole:	ø1.6mm

Actuator specification

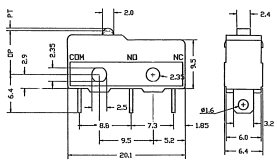
	Button 000	Lever 010	Lever 020	Lever 030	Lever 040	Roller 050	Lever 060	Lever 070	Lever 080
Operating force max (g)	150	42	27	40	42	42	36	42	15
Release force max (g)	75	12	5	8	8	10	5	10	1.0
Pre travel max (mm)	0.6	2.6	4.2±1.2	2.8	2.6	2.6	2.9	2.2	7.5
Movement differential (mm)	0.1	0.6	0.9	0.6	0.6	0.6	0.7	0.5	1.7
Over travel min (mm)	0.5	1.0	1.6	1.0	1.0	1.0	1.2	1.0	5.0

Type No.	Style
CSM3500A or C or D	button
CSM3510A or C or D	lever
CSM3520A or C or D	lever
CSM3530A or C or D	lever
CSM3540A or C or D	lever
CSM3550A or C or D	roller
CSM3560A or C or D	lever
CSM3570A or C or D	lever
CSM3580A or C or D	lever
CSM3590A or C or D	lever
Suffix A = Solder terminal (standard)	
Suffix B = 2.8mm quick connect	
Suffix C = PC terminal (standard)	
Suffix D = 90˚ PC	

Types of Terminal



CSM3500



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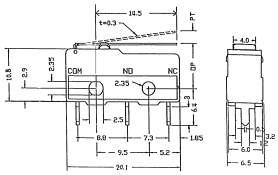

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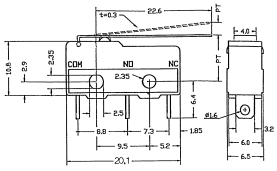

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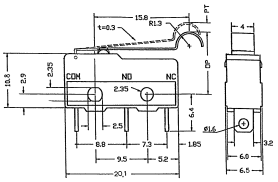

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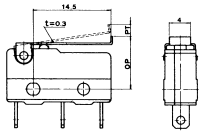

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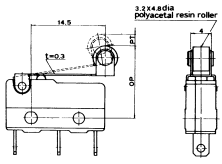

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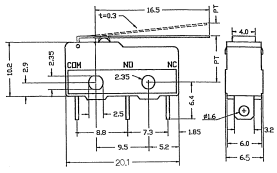

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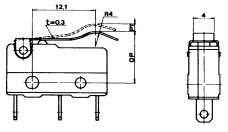

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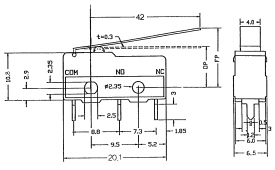

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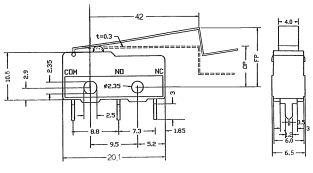

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Because we operate a constant improvement policy, our products are subject to change without notice.

FM28614
BS EN ISO 9002: 1994

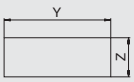
SERIES 1830 - SINGLE POLE AND DOUBLE POLE

ROCKER SWITCHES UP TO 20 (4) A 250 V~

Standard version and appliance cut-out

single pole

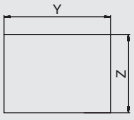
X = panel thickness



X	Y	Z
0.75...1.25	30.0 –0.1	11 +0.1
1.25...2	30.2 –0.1	11 +0.1
2 ...3	30.6 –0.1	11 +0.1

double pole

X = panel tickness



X	Y	Z
0.75...1.25	30.0 –0.1	22 +0.2
1.25...2	30.2 –0.1	22 +0.2
2 ...3	30.6 –0.1	22 +0.2

PRODUCT ADVANTAGES

- Switching principle with long life endurance due to a low friction contact system (ball), proven a 100 million times over
- Attractive rocker switches with a silk matt surface and an abrasionproof marking
- High electrical ratings up to 20 (4) A 250 V~ and inrush current peaks up to 120 A
- Suitable for ambient temperatures up to T 105/55
- Excellent actuation characteristic
- Simple snap-on assembly for appliance panel thickness of 0.75 ... 3.00 mm
- Tight fit in appliance cut-out due to tolerance compensation ribs on the switch housing
- Locked terminals for safe plugging of the connectors

SWITCHING FUNCTIONS

- Single throw (ST) switches
- ST-switches with indicator lamp
- Double throw (DT) switches
- DT-switches with centre-OFF
- Switches with momentary function
- Pilot lights

TERMINAL VERSIONS

- Quick-connect terminal 4.8 mm
- Quick-connect terminal 6.3 mm
- Solder terminal
- Straight PCB-terminal
- Angled PCB-terminal

VERSIONS ON REQUEST

- Flammability according to UL 94 V-0
- Double pole switches with integrated dust protection (see page 2.17)
- With cutting contacts for applications in a dusty environment
- With gold contacts for low voltages
- Additional colours and markings

ACCESSORIES

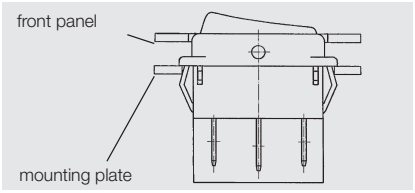
- Protection caps against dust and splash water for double pole switches (Page 2.48)

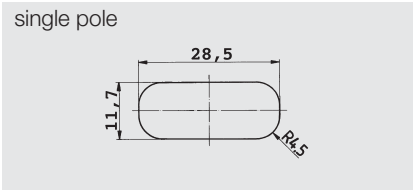
Electrical rating (depending on version)	20 (4) A 250 V~ 10 (8) A 250 V~ 5E4 16 A 125 - 250 V AC 1/3 HP 125 V AC 1 HP 250 V AC
Inrush current ST-switches	120 A capacitive 10^4 operations
Mechanical life endurance ST / DT DT with centre-OFF 5E4	1E5
Contact resistance (new state)	< 100 mΩ (12 V, 1A DC)
Insulation resistance (new state)	> 100 MΩ (500 V DC between the open contacts)
High voltage resistance (new state)	1250 V eff. (between the open contacts) 3750 V eff. (reinforced insulation)
Resistance to tracking	PTI 250
Contact gap	≥ 3 mm
Insulation spacing	≥ 8 mm
Protection type	IP 40
Ambient temperature Terminal side switch not illuminated Terminal side switch illuminated Actuating side	 -20 ... +105 °C no condensation -20 ... +85 °C no condensation -20 ... +55 °C no condensation
Storage temperature	-40 ... +80 °C
Actuating force	3 - 8 N (depending on the switching function)
Flammability	UL 94 V-2
Heat and fire-resistance	850 °C (category D)
Material housing and rocker rocker illuminated	PA PC
Contacts	Ag
Terminals	silver-plated
Temperature rise at the terminals (according to life endurance)	max. 30 K (UL 1054) max. 55 K (EN 61058-1)
Solderability of terminals	max. 350 °C, 3 sec. (without pressure on the terminals when soldering by hand!)
Push-on force of connectors	≤ 80 N
Approval marks	or
Suitable for appliances of protection class II	

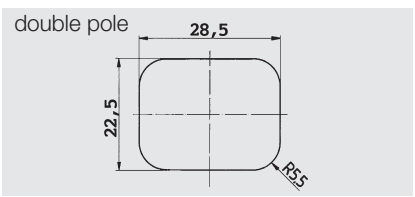
The test conditions comply with EN 610581-1 and UL 1054

INSTALLATION EXAMPLE FOR

switches of the series 1830 with design frame







SERIES 1830 - HIGH INRUSH SINGLE POLE AND DOUBLE POLE

ROCKER SWITCHES UP TO 20 (4) A 250 V~

SINGLE POLE ST-SWITCHES

illuminated

20 (4) A 250 V~
10 (8) A 250 V~ 5E4
5/120 A 250 V~
T 85/55
16 A (1 HP) 250 V AC

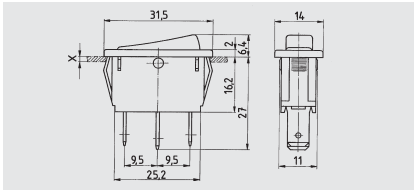
Switches for 125 V AC on request

6.3 1830.3111

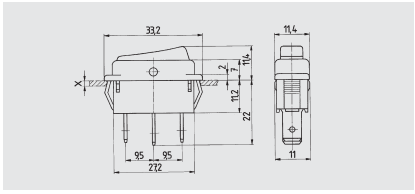
6.3 1830.3112*

6.3 1830.3118*

6.3 1830.8112*



quick-connect terminal 6.3



quick-connect terminal 6.3

DOUBLE POLE ST-SWITCHES

illuminated

20 (4) A 250 V~
10 (8) A 250 V~ 5E4
5/120 A 250 V~
T 85/55
16 A (1 HP) 250 V AC

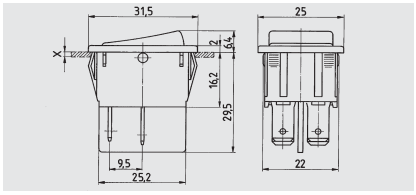
Switches for 125 V AC or 400 V AC on request

6.3 1835.3114

6.3 1835.3112*

6.3 1835.3111

6.3 1835.3118*



quick-connect terminal 6.3

SINGLE POLE ST-SWITCHES

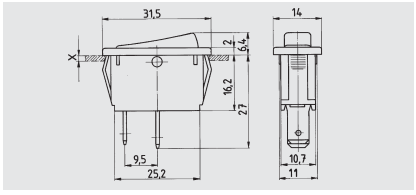
20 (4) A 250 V~
10 (8) A 250 V~ 5E4
5/120 A 250 V~
T 105/55
16 A (1/3 HP) 125 V AC
16 A (1 HP) 250 V AC

6.3 1831.3312*

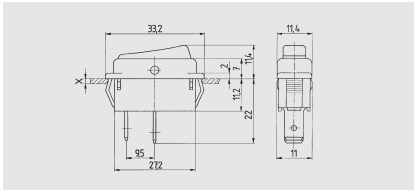
6.3 1831.3313*
4.8 1831.1113
1831.0115

6.3 1831.3933*
1831.0114*

6.3 1831.8112*



quick-connect terminal 6.3



quick-connect terminal 6.3

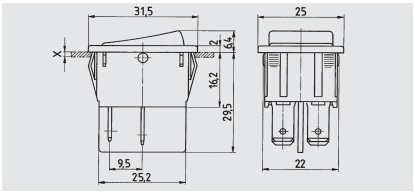
DOUBLE POLE ST-SWITCHES

20 (4) A 250 V~
10 (8) A 250 V~ 5E4
5/120 A 250 V~
T 105/55
16 A (1/3 HP) 125 V AC
16 A (1 HP) 250 V AC

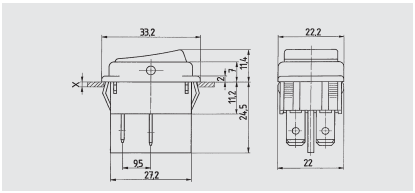
6.3 1832.3312*

6.3 1832.3311*

6.3 1832.8112*



quick-connect terminal 6.3



quick-connect terminal 6.3

SINGLE POLE DT-SWITCHES

10 (4) A 250 V~
6 (4) A 250 V~ 5E4
T 105/55
6 A (1/4 HP) 125 V AC
6 A (1/2 HP) 250 V AC

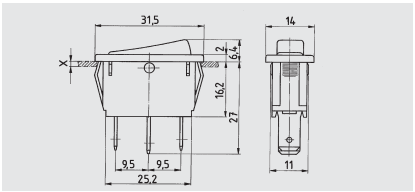
6.3 1833.3302*

6.3 1833.3305*

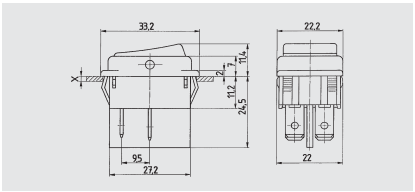
6.3 1833.8102

6.3 1833.3312

16 (4) A 250 V~
T 105/55
16 A (1/3 HP) 125 V AC
16 A (1/2 HP) 250 V AC



quick-connect terminal 6.3



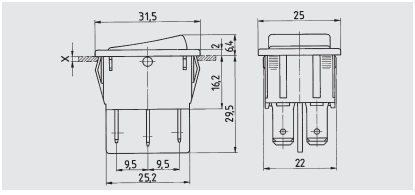
quick-connect terminal 6.3

DOUBLE POLE DT-SWITCHES

10 (4) A 250 V~
6 (4) A 250 V~ 5E4
T 105/55
6 A (1/4 HP) 125 V AC
6 A (1/2 HP) 250 V AC

6.3 1834.3302*

6.3 1834.3309*



quick-connect terminal 6.3

6.3 1834.3312

16 (4) A 250 V~
T 105/55
16 A (1/3 HP) 125 V AC
16 A (1/2 HP) 250 V AC

SERIES 1830 - HIGH INRUSH SINGLE POLE AND DOUBLE POLE

ROCKER SWITCHES UP TO 20 (4) A 250 V~

SINGLE POLE DT-SWITCHES

with centre-OFF

6 (4) A 250 V~
T 105/55
6 A (1/8 HP) 125-250 V AC

without momentary
6.3 1838.3502*
4.8 1838.1502*

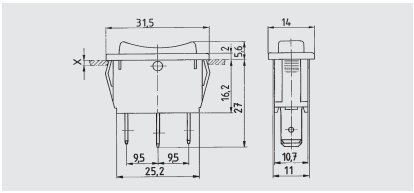
momentary on both sides
6.3 1838.3402*
4.8 1838.1402*

without momentary
4.8 1838.1509*

16 (4) A 250 V~
T 105/55
16 A (1/3 HP) 125 V AC
16 A (1/2 HP) 250 V AC

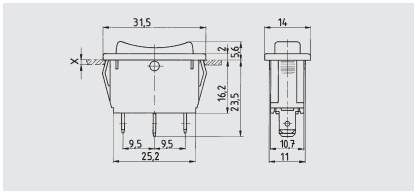
Momentary function on one side on request

6.3 1838.3512



quick-connect terminal 6.3

6.3 1838.3412



quick-connect terminal 4.8

DOUBLE POLE DT-SWITCHES

with centre-OFF

6 (4) A 250 V~
T 105/55
6 A (1/8 HP) 125-250 V AC

without momentary
6.3 1839.3502*
4.8 1839.1502

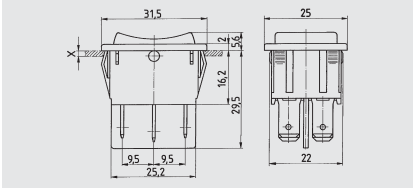
momentary on both sides
6.3 1839.3402*
4.8 1839.1402*

momentary on both sides
4.8 1839.1407*

16 (4) A 250 V~
T 105/55
16 A (1/3 HP) 125 V AC
16 A (1/2 HP) 250 V AC

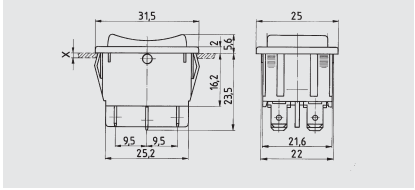
Momentary function on one side on request

6.3 1839.3512



quick-connect terminal 6.3

6.3 1839.3412



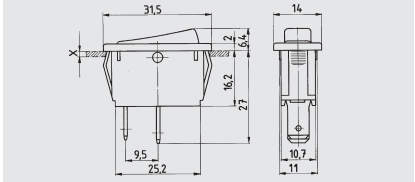
quick-connect terminal 4.8

SWITCHES WITH MOMENTARY FUNCTION

4 (2) A 250 V~
T 105/55
6 A (1/10 HP) 125 V AC
4 A (1/10 HP) 250 V AC

normally open
6.3 1831.3402

DT momentary
6.3 1833.3402



quick-connect terminal 6.3

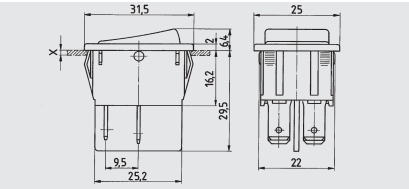
* Version on stock

DOUBLE POLE WITH MOMENTARY FUNCTION

4 (2) A 250 V~
T 105/55
6 A (1/10 HP) 125 V AC
4 A (1/10 HP) 250 V AC

normally open
6.3 1832.3407

DT momentary
6.3 1834.3402*



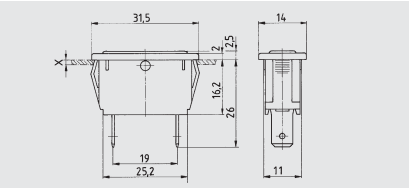
quick-connect terminal 6.3

PILOT LIGHTS

Pilot lights with neon lamp and resistor for 230 V~

Pilot light for 125 V AC according to UL and other colours on request.

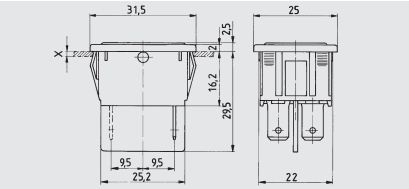
6.3 1837.3102*



quick-connect terminal 6.3 resp. 4.8

6.3 1837.8102*

6.3 1837.8108



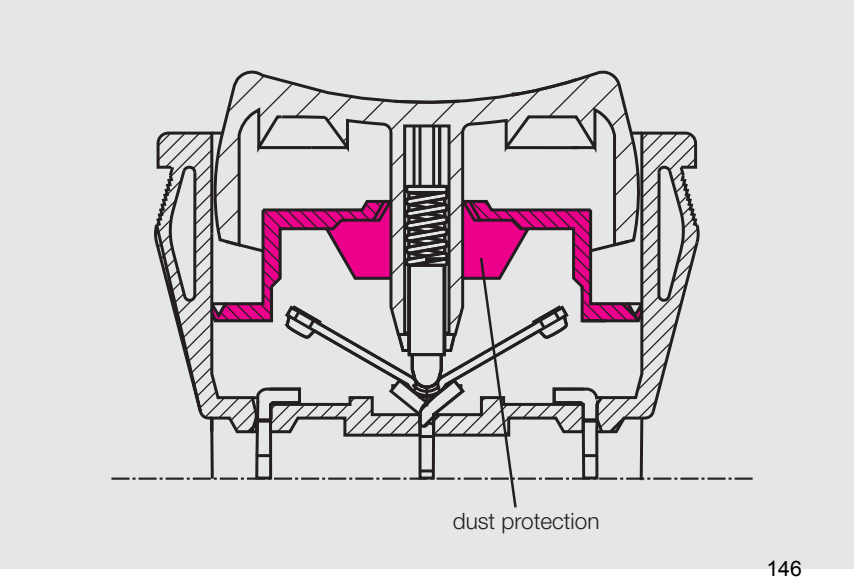
quick-connect terminal 6.3

SERIES 1830 - ROCKER SWITCHES WITH INTEGRATED DUST PROTECTION

ISeveral double pole versions with integrated dust protection are available in the 1830 series.

The diagram opposite shows how the seal in the switch protects the contact system against dust penetration.

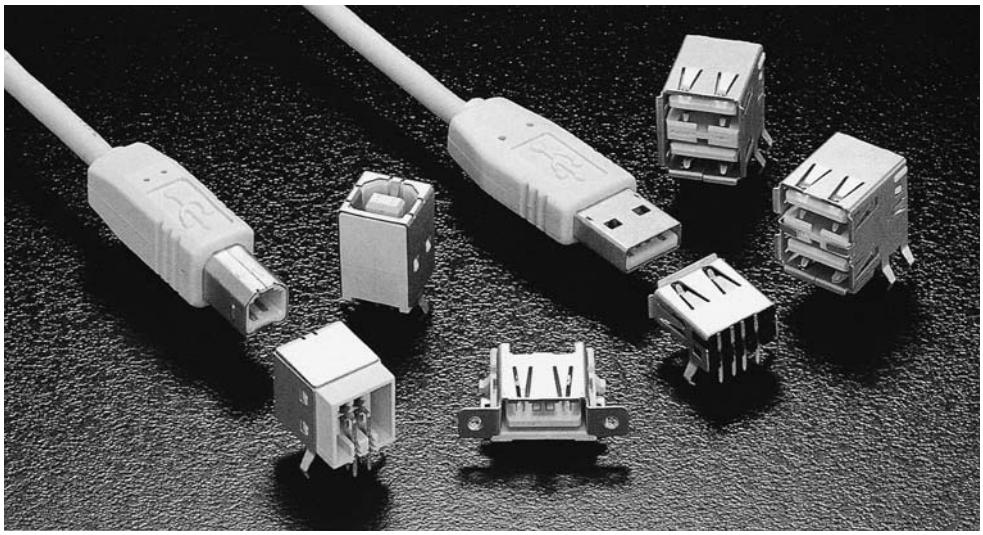
We will gladly supply the switch versions with this dust protection on request.



* Version on stock

Product Facts

- **Plug and Play capability**
- **Hot pluggable, permits attaching or detaching peripherals without power down or reboot**
- **Single 4-position connector, polarized for proper orientation**
- **Complete family of board-mount receptacles, including right-angle, thru-hole, thru-hole type B, side-by-side, and stacked**
- **Cable mount overmold plug kits for both standard and type B applications**
- **Consolidates serial parallel, keyboard, mouse and game ports**
- **Compatible with asynchronous and isochronous data transfer methods**



The Tyco Electronics Connector System will accommodate the two differentially driven data wires that provide bi-directional, simultaneous signals for full speed 12Mbps or for low speed 1.5Mbps used in Universal Series Bus (USB) Systems. The Tyco Electronics USB System is a complete interconnection technology for I/O devices, including: keyboards, mice, game port, serial port devices, digital audio, printers, scanners, modems, joy sticks, and other telecommunication devices. Designed for outside-of-box, user friendly applications, the Tyco Electronics system consists of a single 4-position boardmount receptacle and mating cable mount overmolded plug. Boardmount receptacles are available in standard, Type B, stacked and side-by-side configurations, adding to the system's versatility to meet all USB applications.

Table of Contents

Standard USB

Series A Receptacle Assemblies 2-10
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Mini USB

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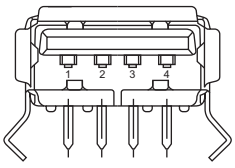
RJ45 Over USB 19

MAG45 Modular Jacks with Integrated Magnetics 20

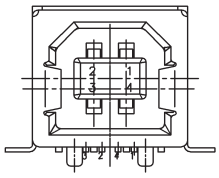
USB/IEEE Combo. 21

Part Matrix

Product	Series	Part Number	RoHS Compliant	Orientation	SMT/ Thru-Hole	Page Number
Header	A	787616-1	202303-1	Right-Angle	Thru-Hole	2
		440260-1	292336-1	Right-Angle	Thru-Hole	2
Header	A	353929-1	5353929-1	Panel Mount, RA	SMT	3
		353928-1	1734038-1	Panel Mount, RA	SMT	4
Header	A	787617-1	5787617-1	Double Stack, RA	Thru-Hole	5
Header	A	440448-1	1-1734181-2	Triple Stack, RA	Thru-Hole	6
Header	A	1470007-2	1-1734383-2	Quad Stack, RA	Thru-Hole	7
Header	A	1364428-1	1734366-1	Vertical	Thru-Hole	8
Plug	A	1470697-1	1734080-1	Edge Mount	SMT	9
		1470695-1	1734028-1	Edge Mount	SMT	9
Plug Kit	A	1364978-1	1734372-1	Cable Appl.		10
Header	B	787780-1	292304-1	Right-Angle	Thru-Hole	11
Header	B	787834-1	5787834-1	Vertical	Thru-Hole	11
Header	B	1734346-1	1734346	Right-Angle	SMT	12
Plug Shell	B	796007-2	796007-3	Cable Appl.		12
Plug Housing	B	796006-4	5796006-4	Cable Appl.		12



Series A



Series B

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Series A Receptacle Assemblies

Right-Angle, Thru-Hole

Part Number
202303-1
Loose Piece

Performance Data

USB Connector System

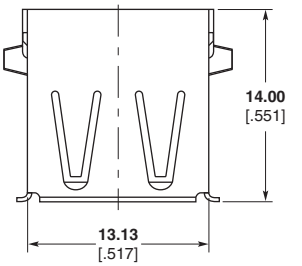
Voltage Rating — 30VAC (rms)
Current Rating — Signal application only, 1 amp per contact
Temperature Rating — –55 to 85˚C (unless limited by cable or overmold)
Termination Resistance — 30mq, max.
Insulation Resistance — 1,000 Mq, min.
Dielectric Withstanding Voltage — 750VAC
Capacitance — 2pf max.
Durability — 1,500 cycles
Mating Force — 35N per contact, max.
Unmating Force — 10N per contact, max.

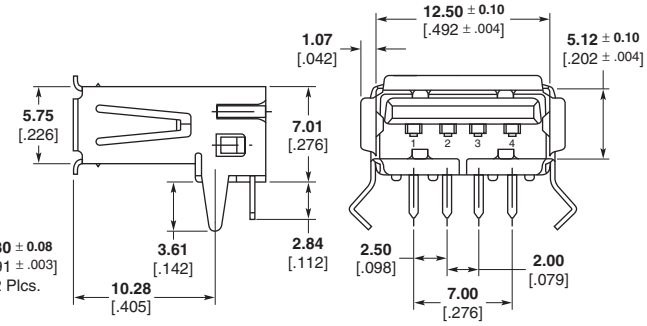
Universal Series Bus

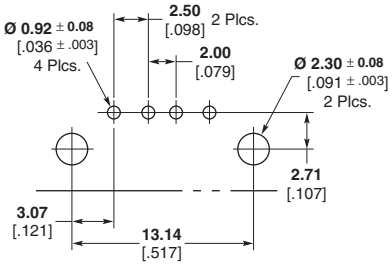
Speed — 12 Mb/s
Max. No. of Peripherals — 63
Max. Distance — 5m max.
Data Transfer — Asynchronous

Solder Tail Length — 2.84 [.112]
Recommended PCB Thickness — 1.57 [.062]

Product Specification
108-1586







Recommended PCB Layout

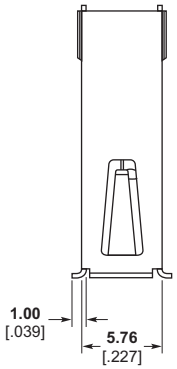
Right-Angle, Thru-Hole, Flag

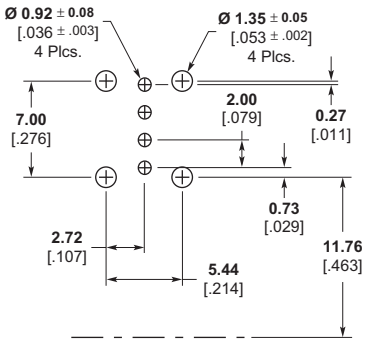
Part Number
292336-1

Loose Piece

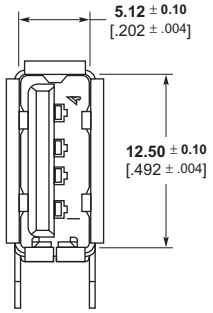
Solder Tail Length — 2.29 [.090]
Recommended PCB Thickness — 1.57 [.062]

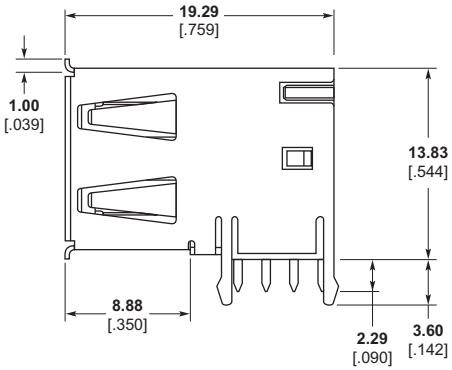
Product Specification
108-1586





Recommended PCB Layout





APPENDIX F

MECHANICAL DRAWINGS

MedTech – MF2003
2008-05-14

Vägg drivsida

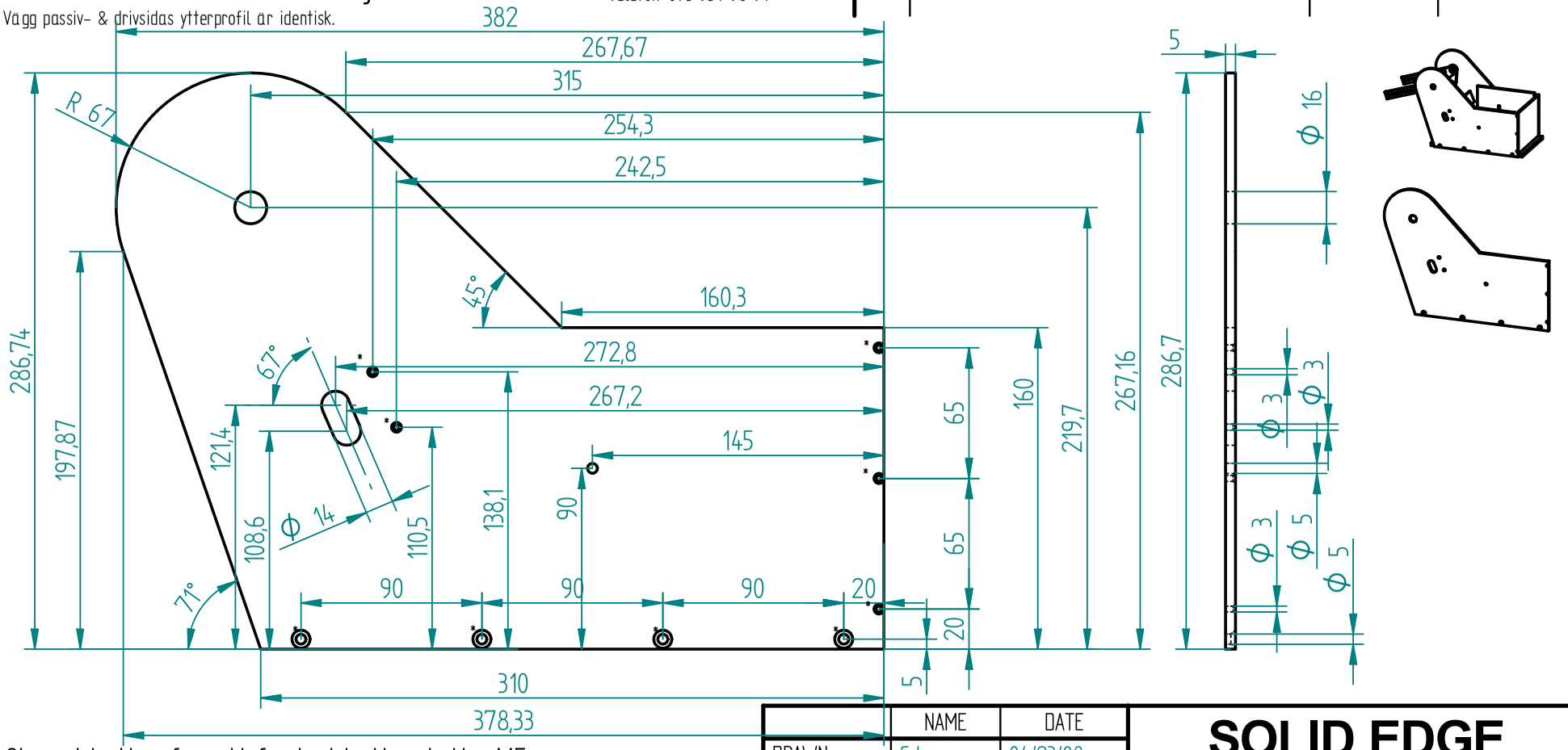
Material: Aluminium 5mm tjocklek.

Vägg passiv- & drivsidas ytterprofil är identisk.

Mekatronik HK – projekt Medtech

Ritningsansvarig: Christian Larsson
Telefon: 073 934 96 94

REVISION HISTORY			
REV	DESCRIPTION	DATE	APPROVED



Skruv i botten för att fästa i bottenplatta: M5
Skruv i högerkant för att fästa i bakplatta: M3

Samtliga hål märkta med * skall försänkas för att dölja skruvhuvudet.

	NAME	DATE
DRAWN	C Larsson	04/23/08
CHECKED		
ENG APPR		
MGR APPR		

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN MILLIMETERS
ANGLES ±X.X°
2 PL ±X.XX 3 PL ±X.XXX

SOLID EDGE
UGS - The PLM Company

TITLE: Medtech prototype

SIZE	DWG NO	REV
A4		

FILE NAME: medtech_ritningar.dft

SCALE:	WEIGHT:	SHEET 1 OF 15

SOLID EDGE ACADEMIC COPY

150

Vägg passivsida.

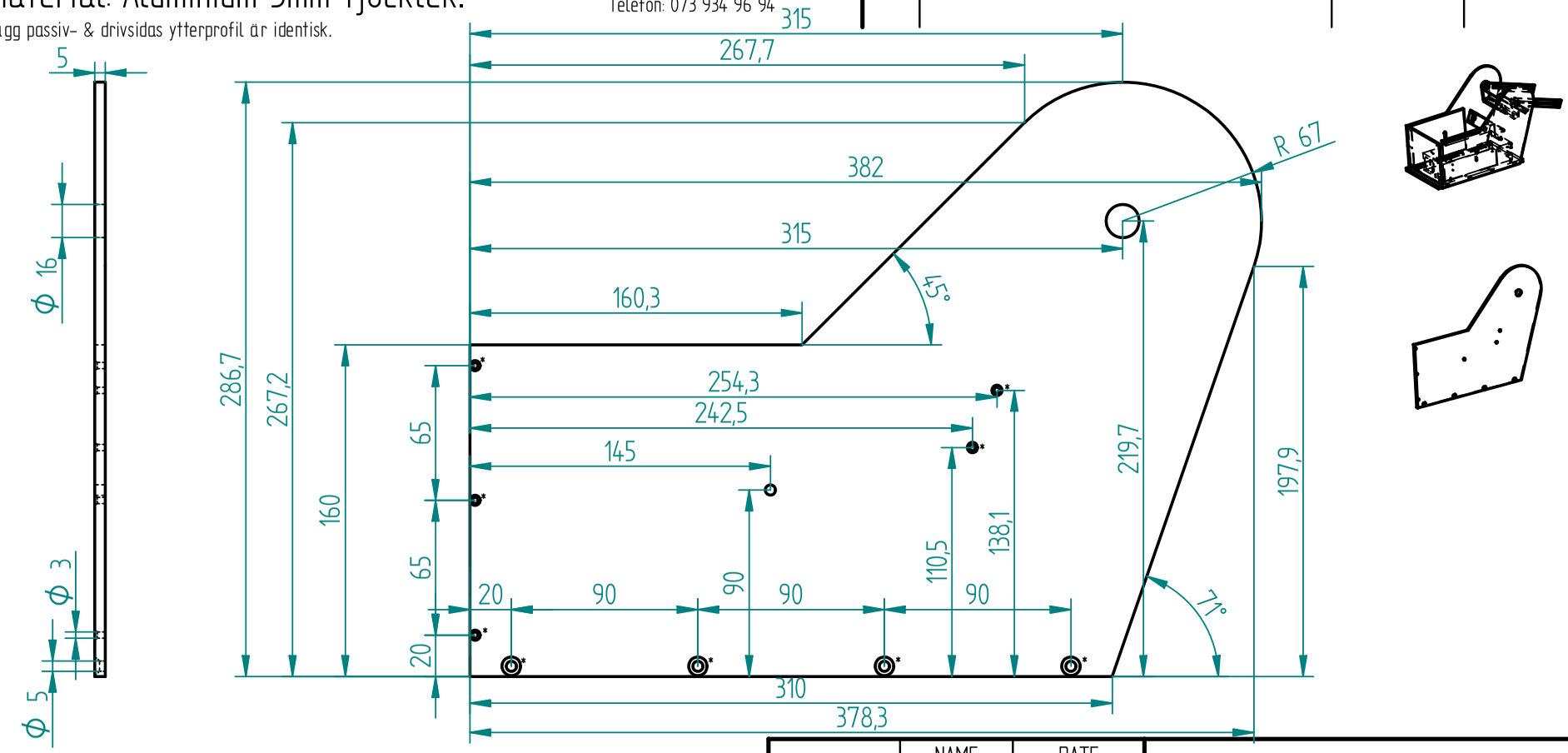
Material: Aluminium 5mm tjocklek.

Vägg passiv- & drivsidas ytterprofil är identisk.

Mekatronik HK – projekt Medtech

Ritningsansvarig: Christian Larsson
Telefon: 073 934 96 94

REVISION HISTORY			
REV	DESCRIPTION	DATE	APPROVED



Skruv i botten för att fästa i bottenplatta: M5
Skruv i vänsterkant för att fästa i bakplatta: M3

Samtliga hål märkta med * skall försänkas för att dölja skruvhuvudet.

	NAME	DATE
DRAWN	C Larsson	04/23/08
CHECKED		
ENG APPR		
MGR APPR		

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN MILLIMETERS
ANGLES ±X.X°
2 PL ±X.XX 3 PL ±X.XXX

SOLID EDGE
UGS - The PLM Company

TITLE: Medtech prototype

SIZE	DWG NO	REV
A4		

FILE NAME: medtech_ritningar.dft

SCALE:	WEIGHT:	SHEET 2 OF 15

SOLID EDGE ACADEMIC COPY

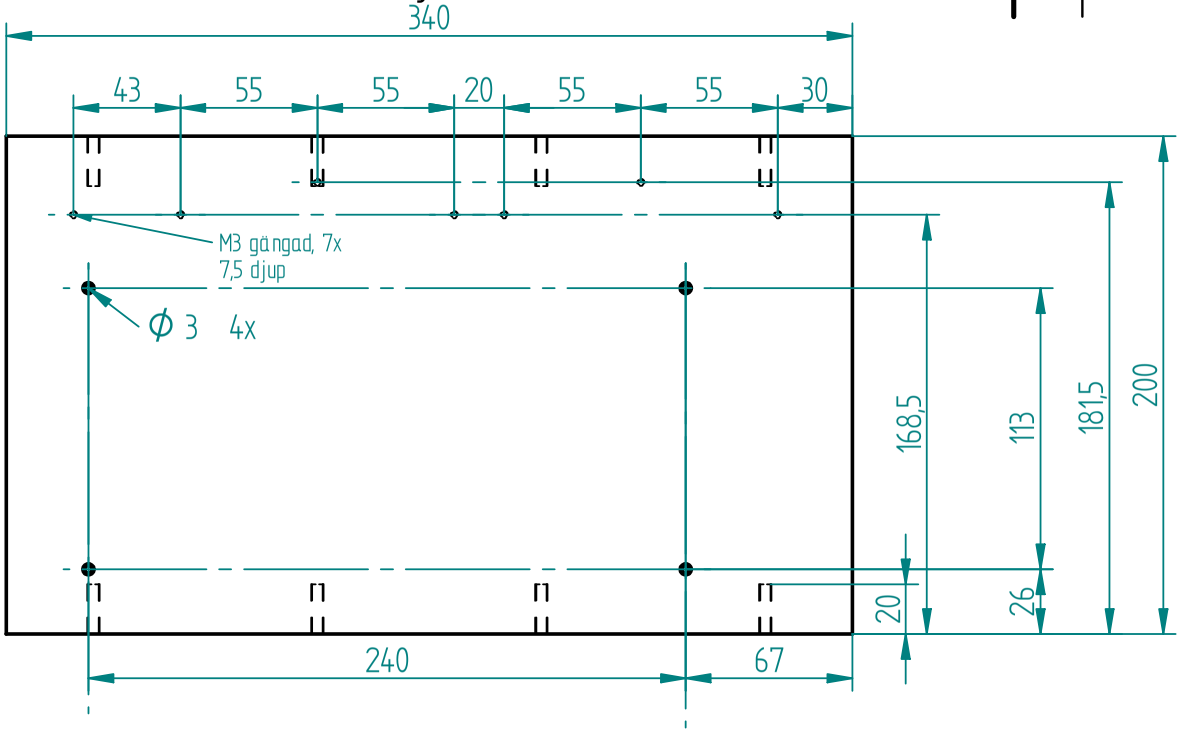
Bottenplatta

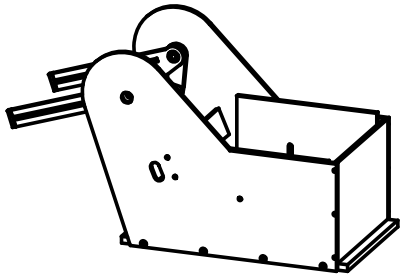
Material: Aluminium 10mm tjocklek.

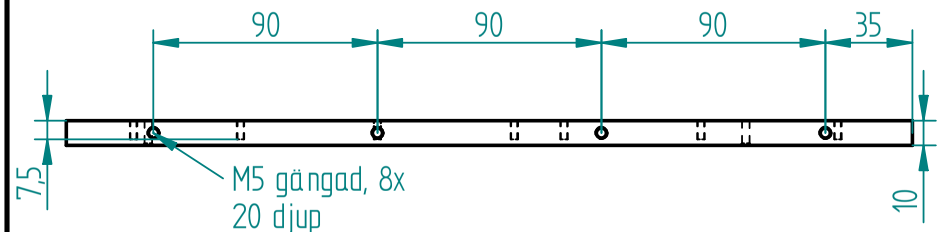
Mekatronik HK – projekt Medtech

Ritningsansvarig: Christian Larsson
Telefon: 073 934 96 94

REVISION HISTORY			
REV	DESCRIPTION	DATE	APPROVED







De åtta hålen längs sidorna skall vara gängade M5.
De sju hålen överst på plattan skall vara gängade M3.
De genomgående fyra hålen försänkta för att dölja skruvhuvud underifrån.

	NAME	DATE
DRAWN	C Larsson	04/23/08
CHECKED		
ENG APPR		
MGR APPR		

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN MILLIMETERS
ANGLES ±X.X°
2 PL ±X.XX 3 PL ±X.XXX

SOLID EDGE
UGS - The PLM Company

TITLE: Medtech prototype

SIZE	DWG NO	REV
A4		

FILE NAME: medtech_ritningar.dft

SCALE:	WEIGHT:	SHEET 3 OF 15

SOLID EDGE ACADEMIC COPY

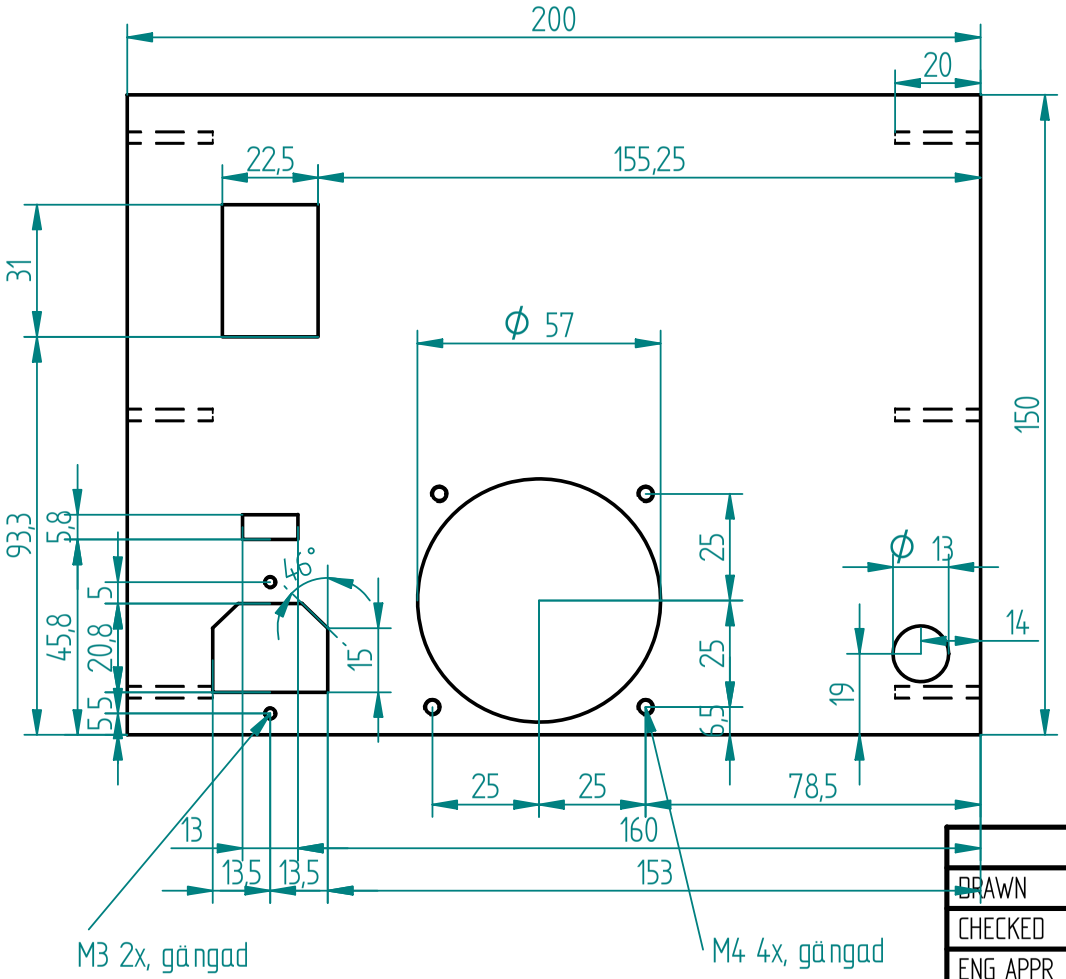
Bakplatta

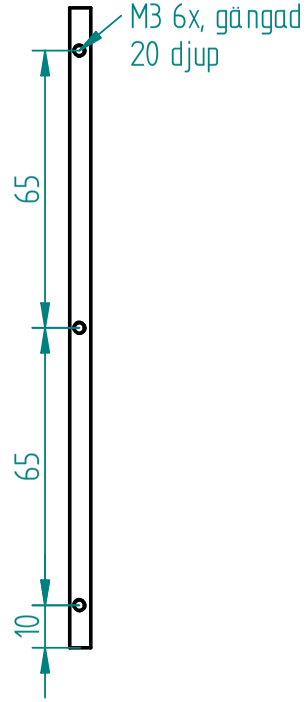
Material: Aluminium 5mm tjocklek.

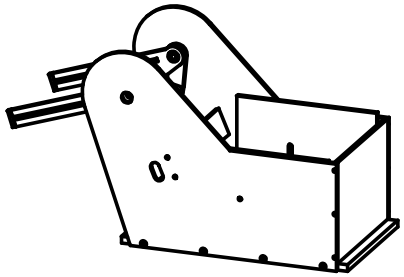
Mekatronik HK – projekt Medtech

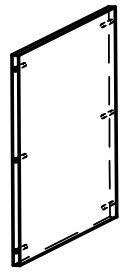
Ritningsansvarig: Christian Larsson
Telefon: 073 934 96 94

REVISION HISTORY			
REV	DESCRIPTION	DATE	APPROVED









	NAME	DATE
DRAWN	C Larsson	04/23/08
CHECKED		
ENG APPR		
MGR APPR		

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN MILLIMETERS
ANGLES ±X.X°
2 PL ±X.XX 3 PL ±X.XXX

SOLID EDGE
UGS - The PLM Company

TITLE: Medtech prototype

SIZE	DWG NO	REV
A4		

FILE NAME: medtech_ritningar.dft

SCALE:	WEIGHT:	SHEET 4 OF 15

153

SOLID EDGE ACADEMIC COPY

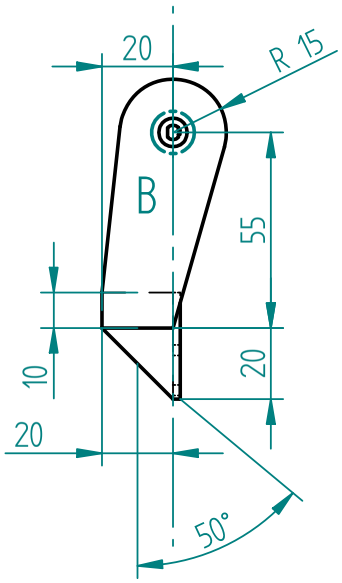
Drivarm

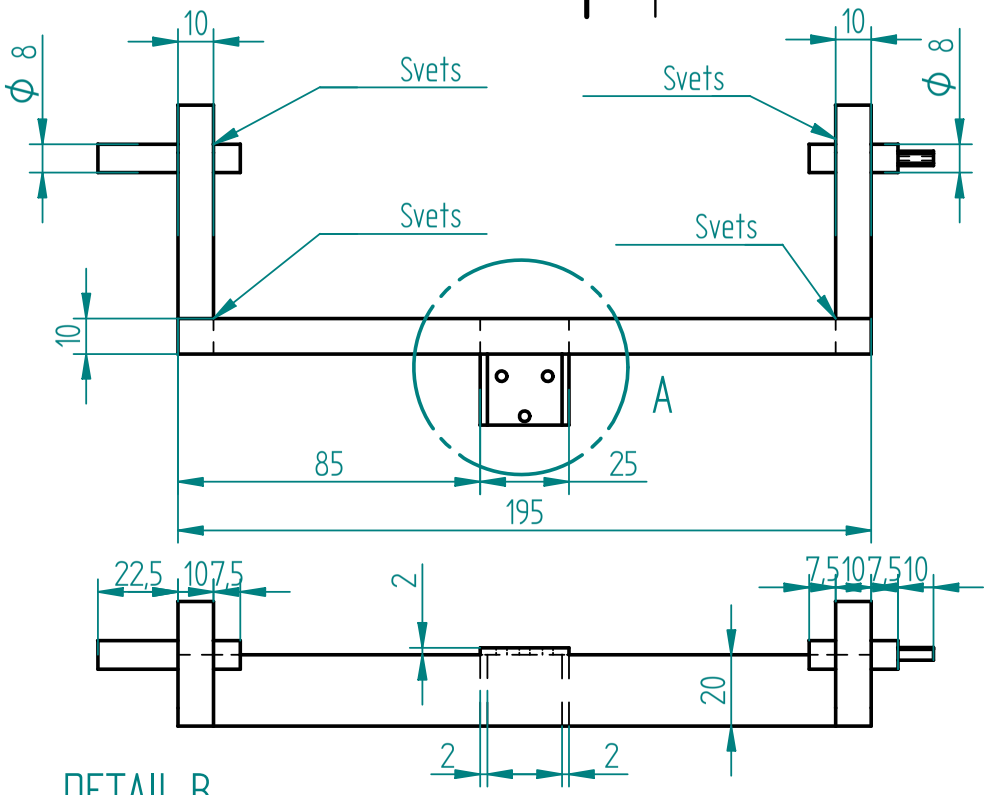
Material: Rostfritt stål

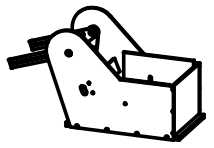
Mekatronik HK – projekt Medtech

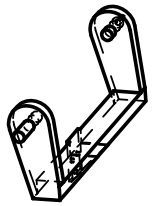
Ritningsansvarig: Christian Larsson
Telefon: 073 934 96 94

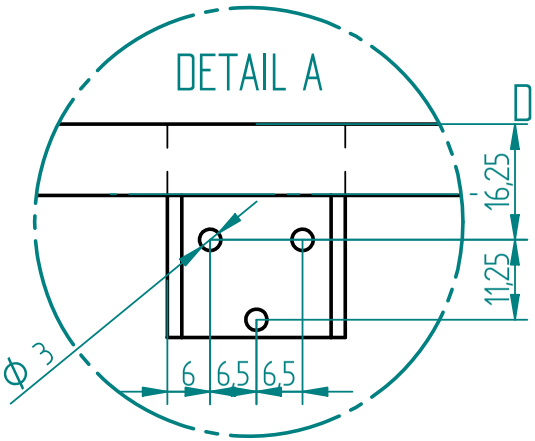
REVISION HISTORY			
REV	DESCRIPTION	DATE	APPROVED

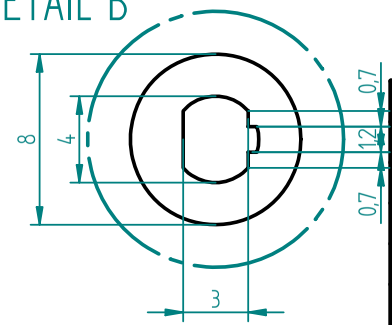












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UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN MILLIMETERS
ANGLES ±X.X°
2 PL ±X.XX 3 PL ±X.XXX

SOLID EDGE
UGS - The PLM Company

TITLE: Medtech prototype

SIZE	DWG NO	REV
A4		

FILE NAME: medtech_ritningar.dft

SCALE:	WEIGHT:	SHEET 5 OF 15

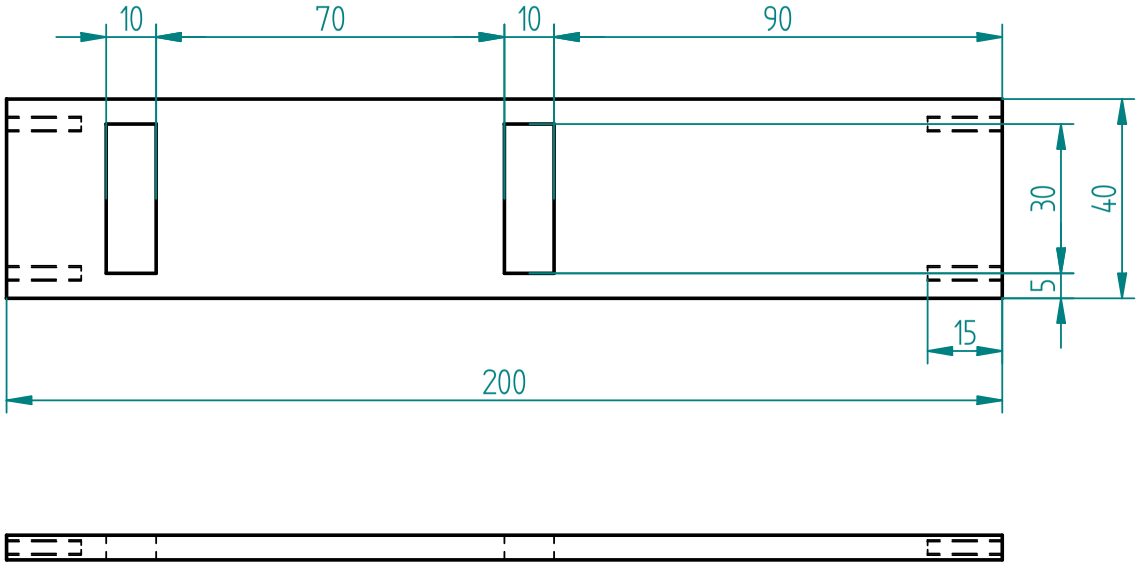
SOLID EDGE ACADEMIC COPY

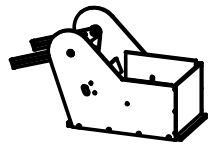
Motorplatta
Material: Aluminium 5mm

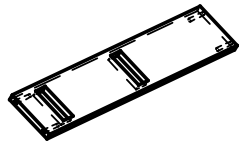
Mekatronik HK – projekt Medtech

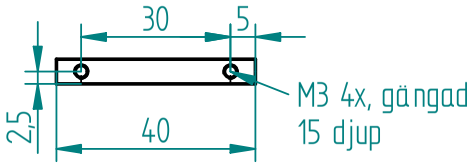
Ritningsansvarig: Christian Larsson
Telefon: 073 934 96 94

REVISION HISTORY			
REV	DESCRIPTION	DATE	APPROVED









Rundade hörn kan tolereras på de rektangulära utfräsningarna.

	NAME	DATE
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2 PL ±X.XX 3 PL ±X.XXX

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TITLE: Medtech prototype

SIZE	DWG NO	REV
A4		

FILE NAME: medtech_ritningar.dft

SCALE:	WEIGHT:	SHEET 6 OF 15

SOLID EDGE ACADEMIC COPY

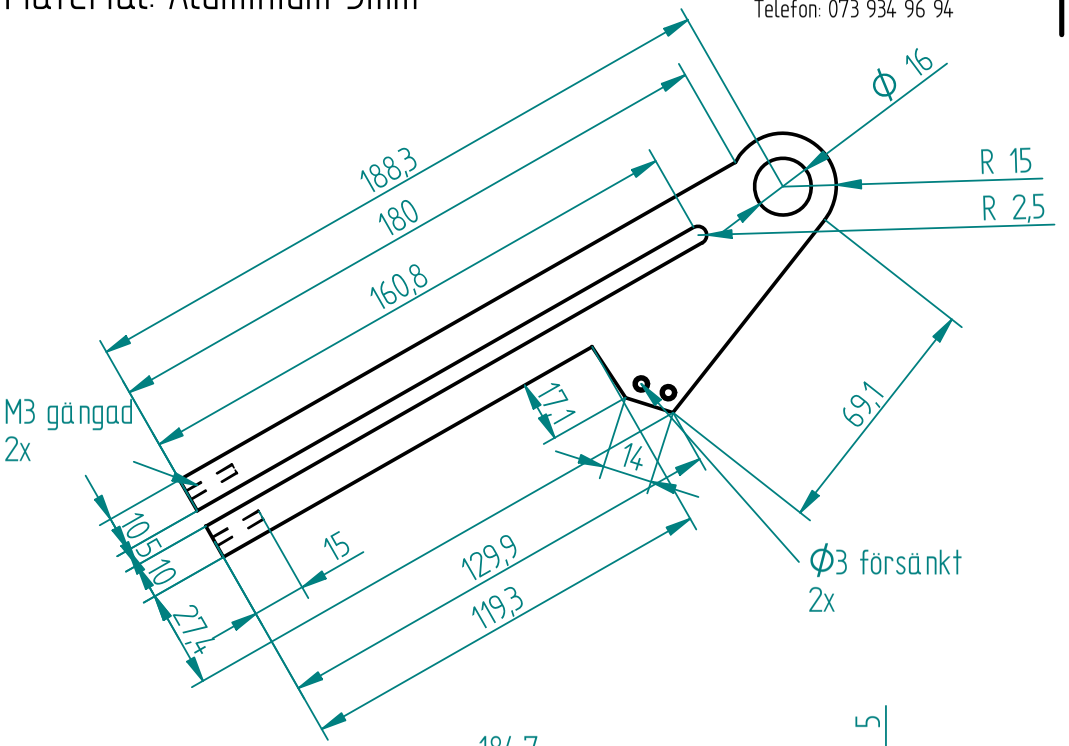
Plattarm

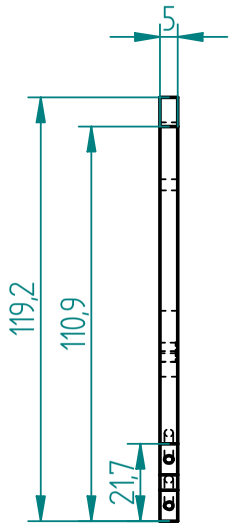
Material: Aluminium 5mm

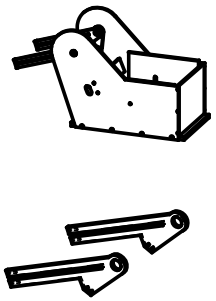
Mekatronik HK – projekt Medtech

Ritningsansvarig: Christian Larsson
Telefon: 073 934 96 94

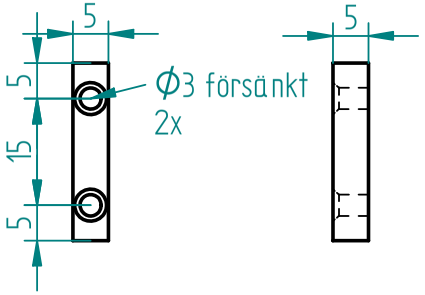
REVISION HISTORY			
REV	DESCRIPTION	DATE	APPROVED

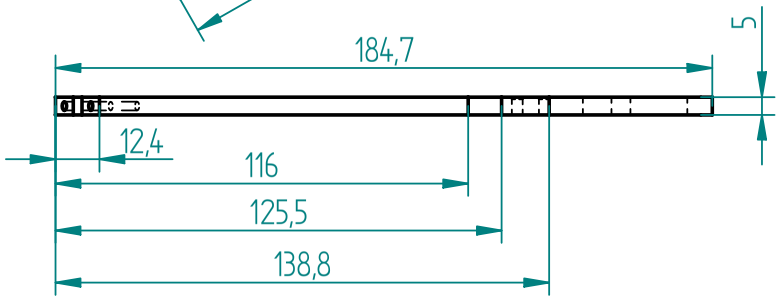






Plattarm ändstopp, 2 st
Material: Aluminium 5mm





Dessa skall tillverkas i två upplagor, spegelvända. Det vill säga, enda skillnaden är från vilket håll som de två hålen försänks.

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2 PL ±X.XX 3 PL ±X.XXX

SOLID EDGE
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TITLE: Medtech prototype

SIZE	DWG NO	REV
A4		

FILE NAME: medtech_ritningar.dft

SCALE:	WEIGHT:	SHEET 7 OF 15

SOLID EDGE ACADEMIC COPY

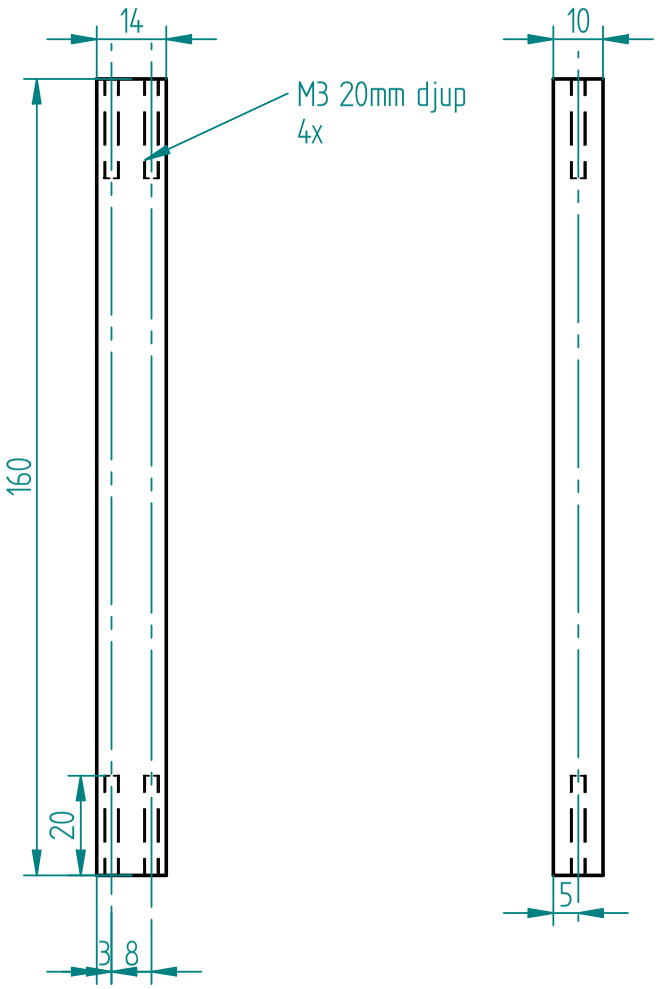
Plattarm mellanstag

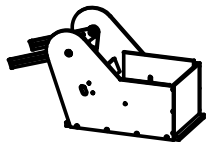
Material: Aluminium el stål 10mm

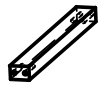
Mekatronik HK – projekt Medtech

Ritningsansvarig: Christian Larsson
Telefon: 073 934 96 94

REVISION HISTORY			
REV	DESCRIPTION	DATE	APPROVED







Om aluminium & rostfritt stål går bra att skruva tillsammans, använd stål. Annars aluminium.–

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2 PL ±X.XX 3 PL ±X.XXX

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TITLE: Medtech prototype

SIZE	DWG NO	REV
A4		

FILE NAME: medtech_ritningar.dft

SCALE:	WEIGHT:	SHEET 8 OF 15

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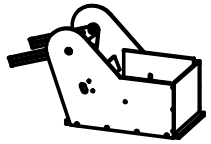
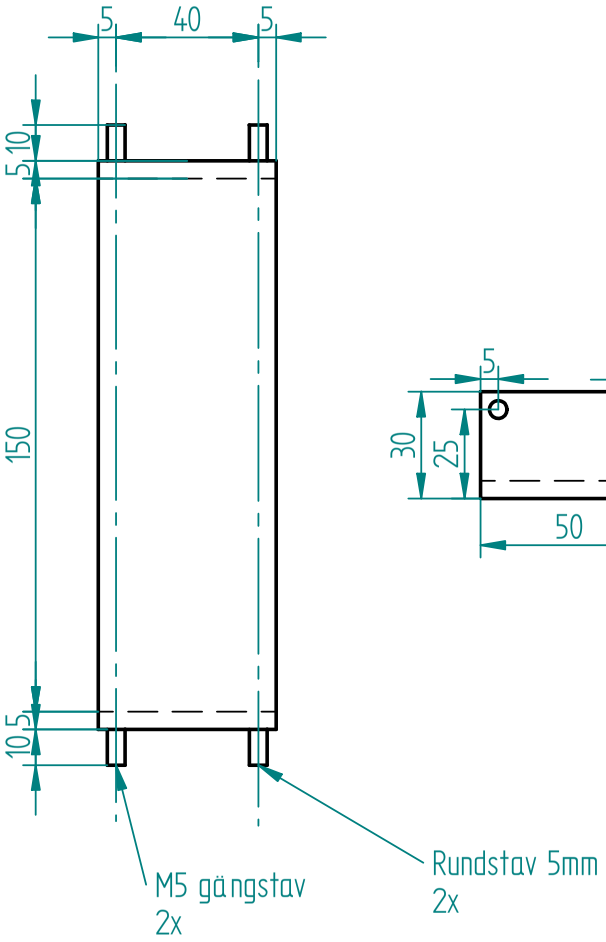
Ram till handplatta
Material: Aluminium 5mm

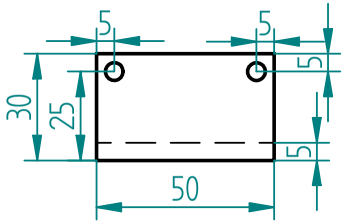
Mekatronik HK – projekt Medtech

Ritningsansvarig: Christian Larsson
Telefon: 073 934 96 94

REVISION HISTORY			
REV	DESCRIPTION	DATE	APPROVED







Ett av pinnparen skall vara gängstav M5.
Ett av pinnparen skall vara rundstav diameter 5mm.

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2 PL ±X.XX 3 PL ±X.XXX

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TITLE: Medtech prototype

SIZE	DWG NO	REV
A4		

FILE NAME: medtech_ritningar.dft

SCALE:	WEIGHT:	SHEET 9 OF 15

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SOLID EDGE ACADEMIC COPY

Armhållare sidovägg, 2 st
Material: Aluminium 5mm

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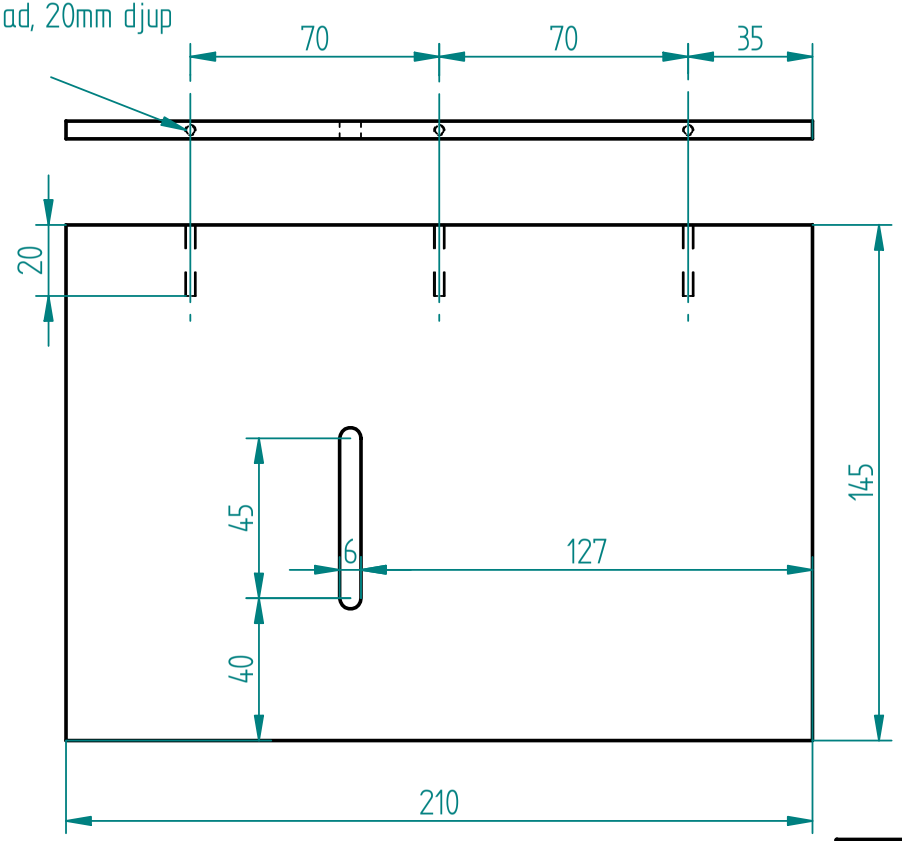
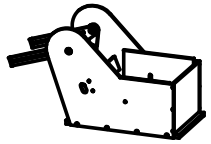
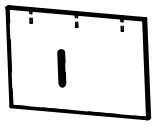
Ritningsansvarig: Christian Larsson
Telefon: 073 934 96 94

REVISION HISTORY			
REV	DESCRIPTION	DATE	APPROVED

M3 gängad, 20mm djup
3x







Det ovala spåret är för att kunna justera armstödet i höjd.

	NAME	DATE
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2 PL ±X.XX 3 PL ±X.XXX

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TITLE: Medtech prototype

SIZE	DWG NO	REV
A4		

FILE NAME: medtech_ritningar.dft

SCALE:	WEIGHT:	SHEET 10 OF 15

SOLID EDGE ACADEMIC COPY

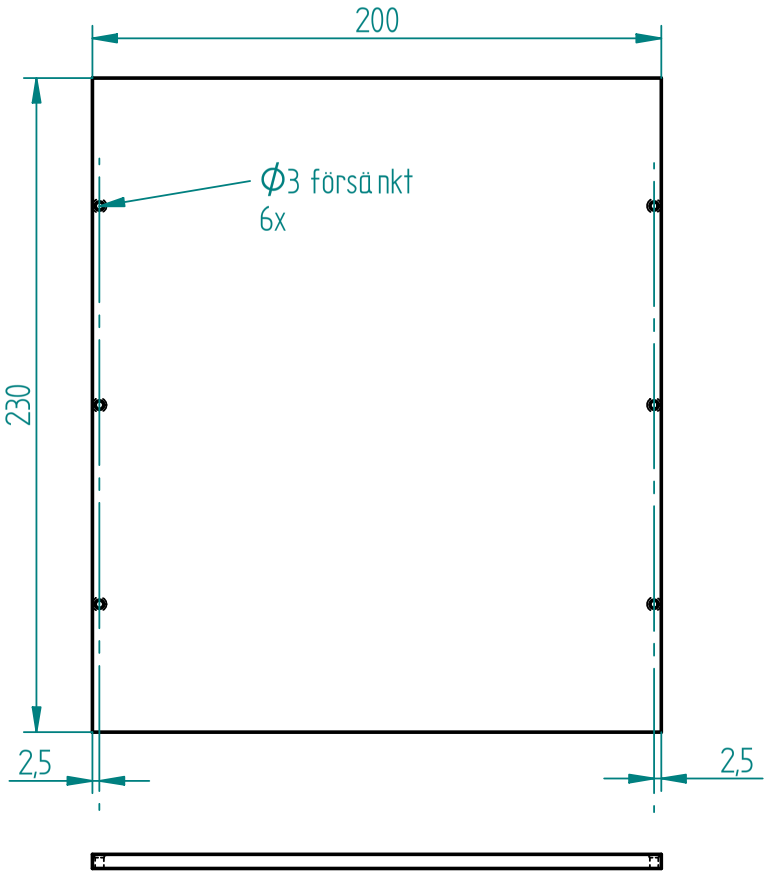
Armhållare tak

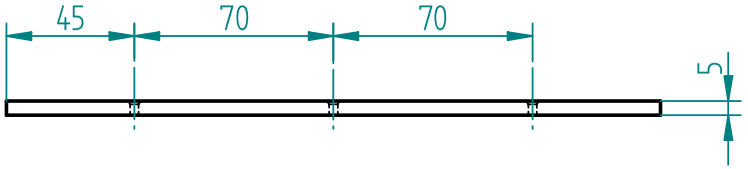
Material: Aluminium 2mm

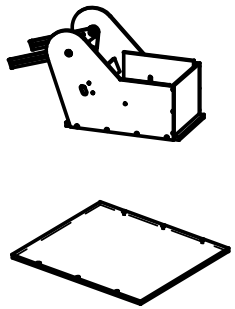
Mekatronik HK – projekt Medtech

Ritningsansvarig: Christian Larsson
Telefon: 073 934 96 94

REVISION HISTORY			
REV	DESCRIPTION	DATE	APPROVED







	NAME	DATE
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ANGLES ±X.X°
2 PL ±X.XX 3 PL ±X.XXX

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TITLE: Medtech prototype

SIZE	DWG NO	REV
A4		

FILE NAME: medtech_ritningar.dft

SCALE:	WEIGHT:	SHEET 11 OF 15

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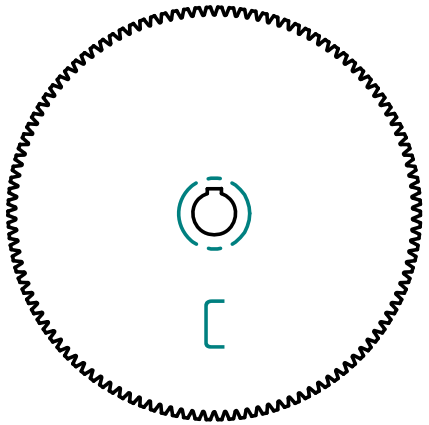
Hål i kugghjul för att passa motoraxeln

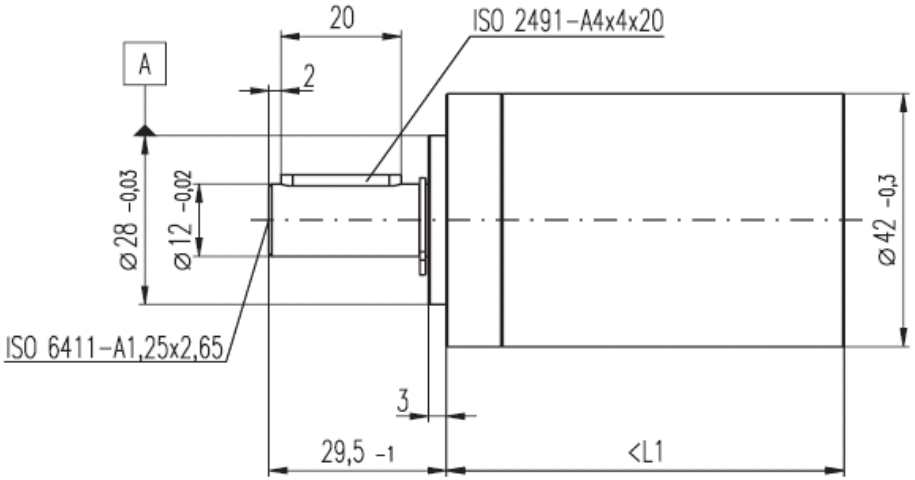
Mekatronik HK – projekt Medtech

Ritningsansvarig: Christian Larsson
Telefon: 073 934 96 94

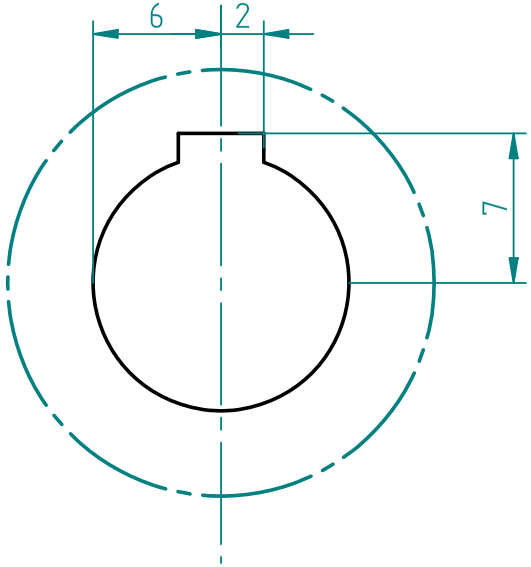
REVISION HISTORY			
REV	DESCRIPTION	DATE	APPROVED



Ritning över utgående axel på växellåda kugghjulet skall passa på



DETAIL C



Måtten på hålet är delvis uppskattade då ISO 2491 inte existerar längre.

	NAME	DATE
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2 PL ±X.XX 3 PL ±X.XXX

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TITLE: Medtech prototype

SIZE	DWG NO	REV
A4		

FILE NAME: medtech_ritningar.dft

SCALE:	WEIGHT:	SHEET 12 OF 15

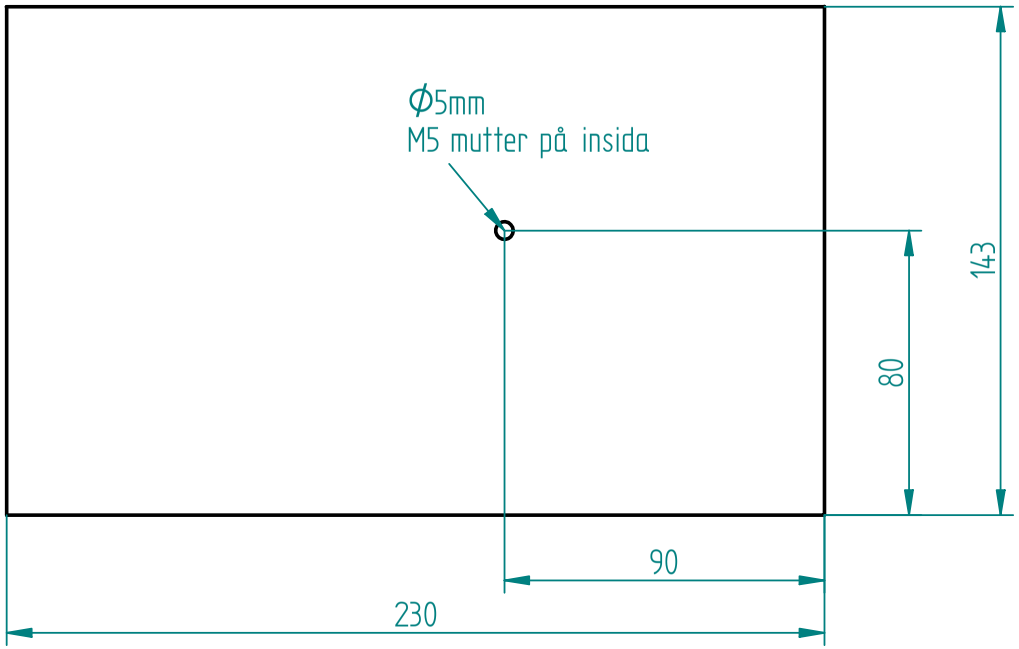
SOLID EDGE ACADEMIC COPY

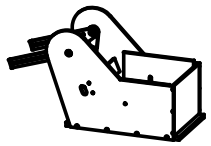
Elektroniklåda väggar, 2 st
Material: Aluminium 2mm

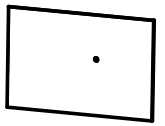
Mekatronik HK – projekt Medtech

Ritningsansvarig: Christian Larsson
Telefon: 073 934 96 94

REVISION HISTORY			
REV	DESCRIPTION	DATE	APPROVED







Dessa väggar skall användas som klämma vid höjdjustering av armstöd. Därför skall en M5-mutter fästas på insidan av väggarna (alltså på olika sidor på de två väggarna).

	NAME	DATE
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2 PL ±X.XX 3 PL ±X.XXX

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TITLE: Medtech prototype

SIZE	DWG NO	REV
A4		

FILE NAME: medtech_ritningar.dft

SCALE:	WEIGHT:	SHEET 13 OF 15

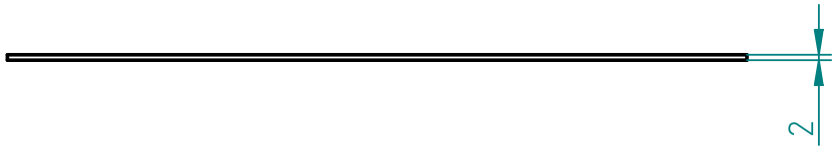
SOLID EDGE ACADEMIC COPY

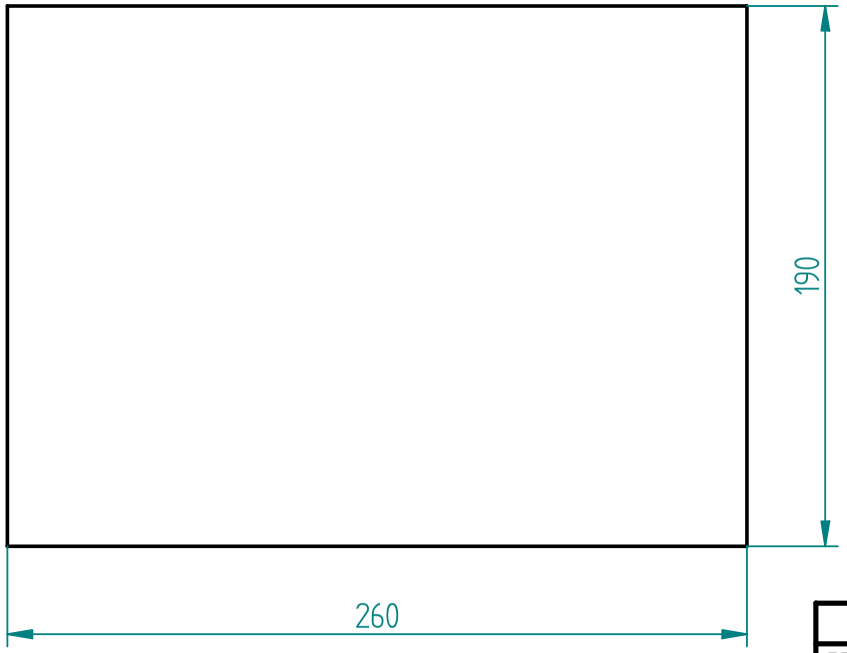
Elektroniklåda tak
Material: Aluminium 2mm

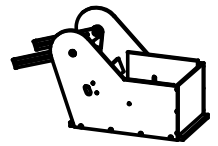
Mekatronik HK – projekt Medtech

Ritningsansvarig: Christian Larsson
Telefon: 073 934 96 94

REVISION HISTORY			
REV	DESCRIPTION	DATE	APPROVED







	NAME	DATE
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2 PL ±X.XX 3 PL ±X.XXX

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TITLE: Medtech prototype

SIZE	DWG NO	REV
A4		

FILE NAME: medtech_ritningar.dft

SCALE:	WEIGHT:	SHEET 14 OF 15

SOLID EDGE ACADEMIC COPY

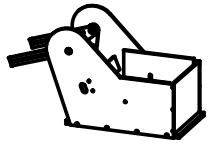
Elektroniklåda distans

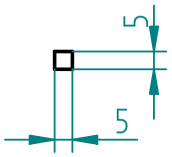
Material: Aluminium 5 mm

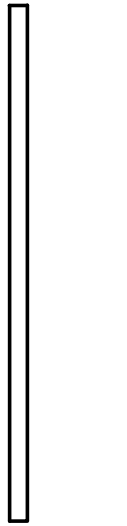
Mekatronik HK – projekt Medtech

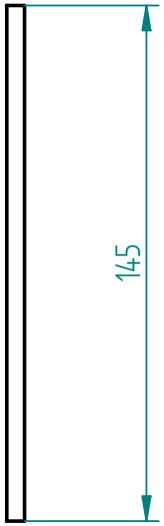
Ritningsansvarig: Christian Larsson
Telefon: 073 934 96 94

REVISION HISTORY			
REV	DESCRIPTION	DATE	APPROVED









	NAME	DATE
DRAWN	C Larsson	04/23/08
CHECKED		
ENG APPR		
MGR APPR		

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN MILLIMETERS
ANGLES ±X.X°
2 PL ±X.XX 3 PL ±X.XXX

SOLID EDGE
UGS - The PLM Company

TITLE: Medtech prototype

SIZE	DWG NO	REV
A4		

FILE NAME: medtech_ritningar.dft

SCALE:	WEIGHT:	SHEET 15 OF 15

SOLID EDGE ACADEMIC COPY

APPENDIX G

TECHNICAL REPORT

MedTech – MF2003
2008-05-13

1 INTRODUCTION

The purpose of this rapport is to clarify requirements on hardware and calculations in software. Its main focus is on sensors, velocity control and the need to accumulate data.

2 MEASUREMENTS

2.1 ACCURACY

The required range of measurements is specified to 0-10 Nm with a margin of error of 0.05 Nm. Because of the requirement on absolute accuracy of 0.05Nm, the tolerance will not be linear throughout the range of measurements. The maximum deviation in percent is calculated at the point where the applied torque reaches 10 Nm [EQ1].

$$\frac{0.05\text{Nm}}{10\text{Nm}} = 0.005 = 0.5\% \quad (1)$$

2.2 RESOLUTION

The resolution on the analog to digital conversion will further diminish the accuracy of the measured torque. If a converter with 10 bits resolution is used, the maximum error will be 0.0049 Nm [EQ2].

$$\frac{10Nm}{1024*2} = 0.0049Nm \quad (2)$$

2.3 ABSOLUTE ERROR

The accuracy on the sensor together with the resolution on the converter in the above setup yields a total maximum error of 0.0549 Nm. This is not is not sufficient according to the specifications. To fulfill the requirements on this point a sensor with better accuracy then 0.5 % must be purchased which, if it exists, would be very costly. In addition, the possible error would only exceed 0.005 Nm in the very end of the range. After discussing this with Anders Fagergren it was agreed that the above accuracy would be sufficient.

3 PERFORMANCE

3.1 VELOCITY

3.1.1 CONTROLLER

Rise time is specified to be 10ms so this is the guideline when deciding the sampling time. To be able to reach a steady velocity within this timeframe there is a need to perform at least 4 samples. The sample time for the regulator is set to 1ms.

3.1.2 MOTOR

A motor that is able to deliver the torque needed to accelerate the load within the specified rise time must be chosen. Calculations show that in a worse case there is a need for approximately 16 Nm [EQ3]. Last year's project group put a lot of energy in choosing a motor. The datasheets on their motor was examined, and it was found that the Maxon DC motor RE40 is able to deliver a stall torque of 2.5 Nm. Since the motor power is shifted with a gear ratio of 43:1 it was found to be good enough, even with a 20% power loss due to gear friction.

$$a_{c\_\max} I_c + M_h g \cdot d + d \cdot Force_{applied} \approx 16Nm \qquad (3)$$

where $a_{c\_\max}$ is the maximum acceleration of the cogs, I_c is the inertia of the cogs, M_h is the mass of a very heavy hand, g is the gravitational constant, d is the distance between the rotational axis (i. e. the wrist) and the hand's centre of gravity and $Force_{applied}$ is the force applied from the patient onto the handlebar.

3.1.3 POWER SUPPLY

The system (including a patient and the mechanical dynamics) was modeled in Matlab Simulink and the current was monitored. The result from the simulations showed that the peaks in current are below 12 A, see Figure 1.

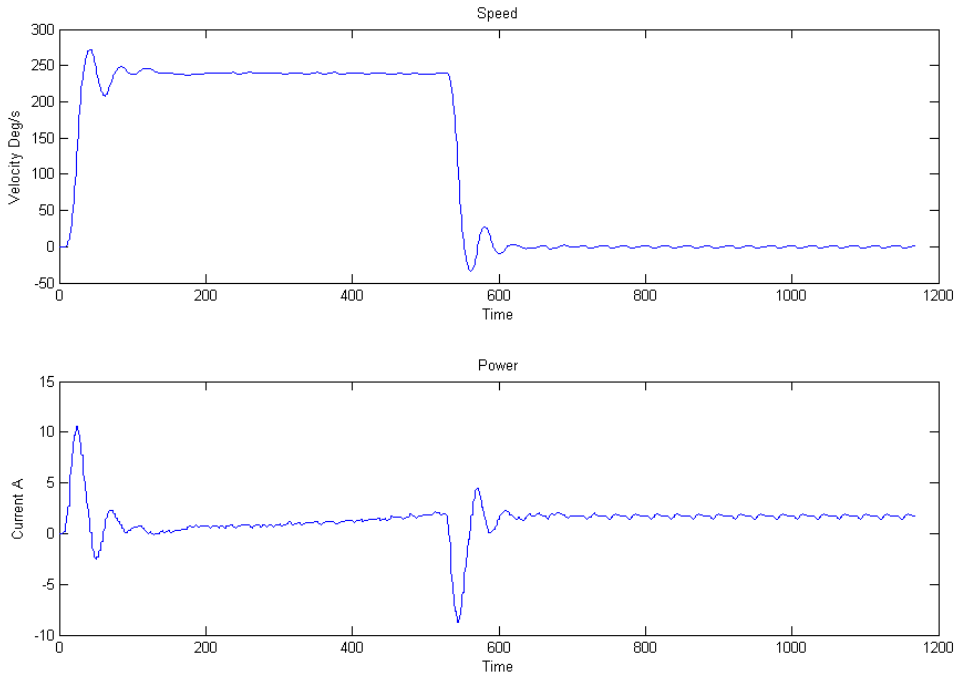


Figure 1 Simulations results

3.2 MICROCONTROLLER

3.2.1 CPU POWER

The sampling period is the key when deciding on clock speed for the CPU. Code for calculating the control law in the regulator consists of simple arithmetic's involving integers and is most certain executed in no more than 100 operations. To maintain good control, care must be taken to make sure that the sampling jitter (the delay from sampling to actuating) is not a considerable part of the sampling period. With a clock speed of 70 MIPS these calculations are performed in less than 1.4 μs which is a but a small fraction of the sampling period of 1ms. [EQ4]

$$\frac{100i}{70mips} \approx 1.4\mu s \qquad (4)$$

3.2.2 MEMORY

During normal operation sampling will be performed every ms, the speed will be approximately 240 degrees per second and the rotational distance will be 50 degrees. The duration of the kinematic operation is calculated in [EQ5].

$$\frac{50Deg}{240Deg/s} \approx 0.21s \tag{5}$$

After the movement is stopped there is a static period of 1s under which measurements are performed with the same frequency. That yields a total time period of 1.21s and with a sampling frequency of 1 kHz. Therefore, 1210 samples will be accumulated. There are two interesting values to be saved, torque and velocity. Since each value is 4 bytes on a 32-bit processor the required memory for these two vectors alone is 9680 bytes [EQ6].

$$1210 * 2 * 4 \approx 9680 \tag{6}$$

APPENDIX H

RISK MANAGEMENT FILE

MedTech – MF2003
2008-05-13

INFORMATION FOR RISK ASSESSMENT FOR SPASTIFLEX PRODUCT

1.1 USER SPECIFICATIONS

- The SpastiFlex is in its current state a product allowed only for usage in a specific hospital research environment and on patients who have signed on their permission. All other kind of usage is today forbidden.
- The product is only developed for the European market, specifically for Sweden. Usage outside Europe is forbidden. This is due to the power supply.
- It's forbidden to use any other power supply than 230V.

The SpastiFlex measures a patient's spasticity in the hand and arm. When using the product, he patient should be in a sitting position. The SpastiFlex can do measurements on either the left or the right arm and hand. The arm is positioned on the armrest and the hook-loop fasteners fasten the arm at two points and also fasten the upper and lower parts of the hand to the hand cradle.

W hen handling the product, the user must take certain risks in consideration. The product may only be used for the specific purpose, which is measuring the spasticity of the hand and arm. If an emergency situation would occur, the emergency stop should be pressed by the user or operator. This action will immediately stop the movement.

1.2 ANTICIPATED MEDICAL DEVICE SPECIFICATIONS

1.2.1 VARIOUS PHASES OF THE WHOLE LIFE CYCLE

The life cycle of the SpastiFlex can be consolidated to six various stages, including design, development, testing, reconstruction, implementation and final usage by Karolinska Institute.

1.2.2 DESIGN DRAWINGS

See Appendix F – Mechanical Drawings.

1.2.3 REQUIRED ENERGY SOURCES AND HOW THEY ARE SUPPLIED

The SpastiFlex needs a power supply of 230V to run. It's supplied via a cord from a wall socket into an appliance inlet.

1.2.4 Documentation on previous designs of similar machinery

See last years report:

Andersson, Tor & Bennwik, Arvid Et al. (2007) *REFLEX - ett medicinsktekniskt utvecklingsprojekt* Stockholm : KTH, Institution Machine design

1.2.5 Information for use of machinery, as available

See Appendix J - User Manual

1.3 Related to regulations, standards and other applicable documents

1.3.1 Applicable regulations

This product is regulated by EU regulatory.

1.3.2 Relevant standards

The considered standard is IEC-60601.

1.3.3 Relevant technical specifications

See Appendix E – Electrical Components & Sensors Datasheet

1.3.4 Safety data sheets

See Appendix J - User Manual

1.4 Related to experience of use

1.4.1 Any accident, incident or malfunction history of the actual or similar machinery

There have been no reports of injury or malfunction of the actual machinery.

1.4.2 History of damage to health resulting from emissions, chemicals used or materials processed by the machinery

No incidents of damage to health resulting from emissions, chemicals used or materials processed by the machinery have been reported.

1.4.3 Relevant ergonomic principles

The product has been designed to fit all users, both young and old. The armrest is designed to be adjustable for this very reason. The hand cradle has a rounded shape on the upper side, to give a comfortable feeling when the hand is strapped to the hand cradle. The hand cradle can also be adjusted in horizontal position to fit all users.

All edges on the frame have been rounded to prevent any cutting injuries. A plastic barrier has been formed to cover the gears and to prevent anyone to get hurt by getting caught in the gears or in other moving parts.

2 Determination of limits of the medical device

2.1 Use limits

2.1.1 Different machine operating modes and the different intervention procedures for the users

The SpastiFlex has an adjustable interface. The range of movement, start and stop, can be adjusted from the GUI to match the physical capabilities of the patient. There is also possibility to adjust the angular velocity if wanted. The GUI is divided into three parts, one simple mode for adjusting velocity and angular parameters, one advance mode for control parameters and an analysis mode where graphs are visualized.

2.1.2 The use of machinery by person identified by sex, age, dominant hand usage, or limiting psychical abilities

The SpastiFlex is designed to fit everyone, in disregard of sex, age or psychical abilities. The product can be used for both the right and the left arm and hand.

2.1.3 The anticipated levels of training, experience or ability of users such as operator, maintenance personnel, trainees, general public

Training is only needed for the operator and should include reading of the User Manual and testing of the functions of the product to become familiar with the GUI, before using it on a patient.

2.1.4 Exposure of other persons associated with machinery; operator working in the vicinity, non-operator employees in the vicinity, non employees like visitors

There is no radiation or other disturbances that affect people in the vicinity.

3 Space limits

3.1.1 Range of movement

The range of movement is from -90 degrees to +90 degrees. The range can thereafter be adapted to the physical limits of current user.

3.1.2 Space requirement for persons to interact with machine

Space required for usage is a table of minimum 50x40 cm, which also allows fastening of the device via two clamps, and a regular chair, that needs to be placed right beside the table. On this table, room has to be given to the emergency stop, so that it has an easy access for both user and operator. A small space is also needed for the operator and the pc that is being used for running the interface.

3.1.3 Human interaction

To interact with the product a pc and a USB-cable are needed. In its current state of development, the SpastiFlex can not be run without a pc and the GUI developed for the usage of the device.

3.1.4 Machine-power supply interface

A power cord from the wall socket into SpastiFlex is needed. To power it up, an on/off button is placed on the back of the device.

4 Time limits

4.1.1 The life limit of the machinery

The life limit of the machinery has been estimated to approximately 5 years.

4.1.2 Recommended service intervals

Every second year an over-all service of the SpastiFlex is recommended. Critical areas are the gear box in the engine and all jointed parts.

5 OTHER LIMITS

5.1.1 ENVIRONMENTAL

The SpastiFlex should not be exposed to any kind of fluids. An exception is for use of fluids for sterilization with a dampened tissue.

5.1.2 SANITIZATION, LEVEL OF CLEANLINESS

The materials used in SpastiFlex are chosen to allow sanitization with regular hospital cleaning detergents (maximum blend of 70% alcohol). The electronic box is not designed to be waterproof and therefore all sanitization should be performed with a dampened tissue or cloth.

5.1.3 PROPERTIES OF THE MATERIALS TO BE PROCESSED

The materials used in the SpastiFlex are aluminum, steel and plastic. The steel consists of stainless steel, and is conductive. The aluminum is conductive and corrosive. The plastic consists of a POM-C which is a semicrystalline thermoplastic and is characterized by a low coefficient of friction and good wear properties, unaffected by wet environments. POM offers good resistance to a wide range of chemicals including many solvents. All parts can be recycled at a recycling station.

Machine	SpastiFlex	Analyst	Jonas Ferngren
Sources	Initial riskassessment	Current Version	1.0
Extent	See phase	Date	2008-04-15
Method	Check lists ISO 14171-1	Page	1

Phases of the machines life cycle		Failure scenarios	Failure Identification			Risk Estimation				Risk Evaluation							Action	
											Residual Risk						If Red or Yellow	
No	Phase/Task/ Function	Hazardeous events or situation	Group of hazard	Orgin	Potential Consequences	Sevirity	Probability	Avoidence	Risk Estimation	Protective Measures and/or validated tests	Sevirity	Exposure	Occurance	Avoidence	Evaluation of residual risk		Responsible	Due Date
1	**Transportation and storage**																	
1.1						1	1	1	2						0			
2	**Installation**																	
2.1						2	1	1	3									
3	**Preparation**																	
						1	1	1	2									
5	**Operation**																	
		Risk of getting caught in the fan	**Pinching hazard**			1	1		2	Fan grate								
		Hand whip on a third part	**Pinching hazard**			2	2		4	A barrier for accelerations; a shell								
		Risk of getting caught between the steel arms and the base plate	**Pinching hazard**			1	2		3	The plain bearing. Should not go below the edge of the table								
		Risk of getting caught between the armrest and the walls	**Pinching hazard**			1	2		3	A gap maximum of 5mm								
		Risk of getting caught in the cords of the load sensor	**Pinching hazard**			1	1		2	Cords should be mounted inside the arms								
		Risk of getting caught between the gears	**Pinching hazard**			2	2		4	A shell and a position fail safe solution.								
		Risk of getting caught in the bearings	**Pinching hazard**			1	1		2	A gap maximum of 5mm								
		Risk of chafes from the hook-and-loop fasteners	**Pinching hazard**			1	1		2	Look at used solutions for athletic protection								
		Risk of getting caught between the load sensor and the sleigh	**Pinching hazard**			2	2		4	A distance of 20mm, a transparent plastic								
		Influence of vibrations on other instruments	**Vibrations**							A product requirement								
		The device is dropped on the foot during transportation	**Stability**			2	1		3	Mouse-pad material for friction damping								
		The device doesn't stay at the table	**Stability**			1	1		2	Bar clamps and information								
		The device falls down while the patient is strapped to it	**Stability**			3	1		4	Information in the manual. A hold in the table								
		The noise level	**Sound**			1	1		2	Recommended level 55dB. Check IEC-60601. Isolate the shell.								
		Risk of rust on the metal parts	**Materials**			1	1		2	Stainless steel. Check IEC-60601								
		Nickel allergy	**Materials**			1	1		2	Look-up the materials								
		The plastic barrier gets overheated	**Thermical**			2	1		3	Themal conductivity. Fire Hazard classification								
		The windings get overheated	**Thermical**			2	1		3	IEC-60601 provides tests for this								
		Burn due to burning komponents while strapped to the device	**Thermical**			2	1		3									
		Chemicals allowed on the product	**Chemicals**							Usage of ethanol 20% and 70%. Information in the manual								
		Risk of spilling fluids over the device	**Chemicals**							IP classification 2 4 (dust and water). Gortex filter								
		Difficulty of sterilization of all parts	**Chemicals**							Rounded shapes								
		Bends the hand too hard - whip	**User**							Maximum torque. Dead man's grip.								
		Too large range of movement	**User**							Inform in the manual. Check the range of movement. Barriers. Graphical illustration in the GUI								
		Electrical cords might come loose during execution	**Electronics**							Stoppage. Tools needed to remove the cables. Check IEC-60601								
		Conductive	**Electronics**							Safety earthing. Correct choice of cable covering. The plastic shell shall not be conductive.								
		EMC	**Electronics**							60601-2 provides tests for this. There are 5 tests, provided by among others Semco.								
		Connect 230 V without being certified	**Electronics**							Inform in the manual. Check with an authorized electrician								
		ESD	**Electronics**			1	1		2	Choice of materials. ESD-safe plastic								
		Certified power supply net	**Electronics**							NEC70 (USA).								
		Transformator not approved for 110V	**Electronics**							UL-safe and EN-safe								
		Fire hazard	**Electronics**							Fire Hazard classified PCBs								
		Armrest can be conductive	**Electronics**			2	1		3	Earthing.								
		Gear teeth's breaks and are propelled	**Mechanical**			1	1		2	Safety shell. Switch.								
		Emergency stop is blocked	**Mechanical**							Dead man's grip. 2 emergency stops or 1 meter cord. No pinching hazard.								
6	**Cleaning and Sanitazion**								0									
7	**Troubleshooting**																	
									0									
8	**Maintenance**																	
									0									
9	**Decommissioning recycling**																	
									0									
10	**Marking and Information**																	

Risk assessment; Reference guide between MD 98/37/EC and Harmonised Standards

The MD text are copied into the comments

Reference guide for the Wave Bioreactor conformance to the Machinery Directive

Machinery Directive 98/37/EC		MD		LVD	EMC	Other relevant standards
#	**Heading**	EN 12100-1 sub clauses	EN 12100-2 sub clauses	EN 61010-1	EN 61326-1	
1.1	**Essential Health and Safety Requirements**			LVD	EMC	
	General remarks	1	1			
1.1.1	Definitions	3		3	x	
	Danger Zone	3				
	Exposed Person	3				
	Operator	3				
1.1.2	Principles of safety integration	5	4			
			5			
			6			
1.1.3	Materials and products	4,8				
1.1.4	Lighting					
1.1.5	Design of machinery to facilitate its handling	5	4	14		
			5,5,5			
1.2	**Controls**		4,11			
1.2.1	Safety and reliability of control systems		4,11,1			ISO 13849-1
			4,11,9			
1.2.2	Control devices		4,11,1			
1.2.3	Starting		4,11,2	6.10		
			4,11,3			
1.2.4	Stopping device NORMAL		4,11,3	6.11		
	emergency stop		5,5,2	6.11		ISO 13850, IEC 954
1.2.5	Mode selection					
1.2.6	Failure of power supply		4,11,4	6.5		

			4,11,5			
1.2.7	Failure of the control circuit		4,11,7,2	6.11,14.9		IEC 61508
1.2.8	Software		4,11,7,3			IEC 61508-3
			4,11,7,4			
1.3	**Protection against mechanical hazards**	4,1	4,2 - 4,8	7		
1.3.1	Stability		4,6	7.3		
			5,2,6			
1.3.2	Risk of break-up during operation		4,3	8		
1.3.3	Risks due to falling of ejected objects					
1.3.4	Risks due to surfaces, edges or angles		4,2,1			ISO 13852, 13853, 13854
1.3.5	Risks related to combined machinery					
1.3.6	Risks relating to variations in the rotational speed of tools		4,2,2			
1.3.7	Prevention of risks related to moving parts		4,2,2	7.2		
1.3.8	Choice of protection against risks related to moving parts		5,2,5	7.2		
			5,3			
1.4	**Required characteristics of guards and protections devices**		5			
1.4.1	General requirements		5,2,5			
1.4.2	Special requirements for guards		5,3			
1.4.2.1	Fixed guards		5,3,2,2			
1.4.2.2	Movable guards		5,3,2,3			ISO 14119
1.4.2.3	Adjustable guards restricting access		5,3,2,4			
1.4.3	Special requirements for protection devices		5,3,2,5			ISO 14119
1.5	**Protection against other hazards**					
1.5.1	Electrical supply	4,3	4,9	6		

1.5.2	Static electricity	4,3			X	
1.5.3	Energy supply other than electricity		4,1			ISO 14118:2000 CH 5
1.5.4	Errors of fitting					
1.5.5	Extreme temperatures	4,4		10		
1.5.6	Fire	4,4		9		
1.5.7	Explosion	4,4		9.4		
1.5.8	Noise	4,5	5,4,2	12.5		ISO 15667, ISO 14163
1.5.9	Vibration	4,6	5,4,3			EN 1299
1.5.10	Radiation	4,7	5,4,5	12.1	X	IEC 61326-1
1.5.11	External radiation	4,7	5,4,5	12.1, 12.3	X	IEC 61326-1
1.5.12	Laser equipment	4,7	5,4,5	12.6		
1.5.13	Emission of dust, gases, etc.	4,8	5,4,4	9.4		ISO 14123-1
1.5.14	Risk of being trapped in a machine	4,1	5,5,3			
1.5.15	Risk of slipping, tripping or falling	4,11	4,8			
1.6	**Maintenance**		4,7			
1.6.1	Machinery maintenance		4,7			
1.6.2	Access to operating position and servicing points		5,5,6			
1.6.3	Isolation of energy sources		5,5,4			ISO 14118:2000 CH5
1.6.4	Operator intervention		5,5,6			ISO 14122 SERIES
			4,15			
1.6.5	Cleaning of internal parts		4,11,9			
1.7	**Indicators**		6			
1.7.0	Information devices		6,2			IEC 62079
1.7.1	Warning devices		6,3			IEC 62079, ISO 7000
1.7.2	Warning of residual risks		6,1,1			IEC 62079
1.7.3	Marking		6,4	5		ISO 2972, ISO 7000
				5,1		
				5,2		
				5,3		
1.7.4	Instructions		6,5	5,4		IEC 62079
2.1	**Agri-foodstuffs machinery**					

	Sanitary design for the Bioprocessing Industry					

Terms and definition

Harm	psysical injury or damage to health
Hazard	Potential source of har
Hazard zone	any space within and/or around the machineryin which a person may be exposed to a hazard
Hazardeous events	Event that can cause harm
Hazardeous situation	circumstances were a person is exposed to at least one hazard
Intended use of the machinery	
Machinery	
Malfunction	failure of a machine to perform an intended function
Protective measures	measures intended to achieve risk reduction
Reasonable forseable misuse	Use of a machine in a way not intended by the designer, but which may result from readily predictable human behaviour
Residual risk	Risk remaining after protective measures have been taken
risk	Combination of the probability of occurence of harm and the sevirity of that harm
risk analysis	combination of the specification of the limits of the machine, hazard identification and risk estimation
risk assessment	Overall process comprising a risk analysis and a risk evaluation
risk estimation	definition of likely sevirity of harm and probability of its occurence
risk evaluation	Judgement of the basis of risk analysis, of whether the risk reduction objectives have been achieved
task	Specific activity performed by one or more persons on or its vicinity of the machine during its life cycle

Risk assessment Quantification according to ISO 14171					
Consequences Class	**Severity**	**Probabillity**		**Avoidence**	
Catastrophic	5	Frequent	5		
Critical	4	Probable	4		
Serious	3	Occasional	3	Impossible	5
Minor	2	Remote	2	Rarely	3
Negliable	1	Improbable	1	Possible	1

No	Phases during the machines life cycle	Tasks identification
1	Transport Assembly Installation	Setting Testing teaching/ programming Process/ Tool changeover
2	Commissioning	Start up All modes of operation
3	Use Preparation, Operation, post-run activities, maintenance	Feeding machine Removal of product from the machine
4	De-commissioning Dismantling Disposal	Stopping the machine Stopping the machine in an emergency Recovery of operation from jam Re-start after unshedueled stop Faultfinding/ Trouble-shooting (Operator intervention) Cleaning and housekeeping Preventive maintenance Corrective maintenance

No	Phases during the machines life cycle	Tasks identification
1	**Transport**	Lifting Loading Packing Transportation Unloading Unpacking
2	**Assembly and installation** **Commissioning**	Adjustment of the machine and its components Assembly of the machine Connecting to disposal system Connecting to power supply Demonstration

		Feeding, filling, loading of ancillary fluids (lubricant, grease, glue) Fencing Fixing and anchoring Preparations for the installation Running the machine without load Testing Trials with loads or maximum load
3	**Setting** **Teaching/ Programming** **Process change over**	. Adjustment and setting of protective devices and other components Adjustment and setting or verification of functional parameters of the machine (speed, pressure, force, travelling limits) Clamping/ fastening the workpiece Feeding, filling, loading of raw material Functional test trials Mounting or changing tools, tools setting Programming verification Verification of the final product .
4	**Operation**	Clamping/ fastening the workpiece Control/ inspection Driving the machine Feeding, filling, loading of raw material Manual loading/ unloading Minor adjustment and setting of functional parameters of the machine (speed, pressure, force, travel limits Minor interventions during operation (removing waste material, eliminating jams, local cleaning Operating manual controls Restarting the machine after stopping/ interuption Supervision Verification of the final product
5	**Cleaning** **Maintenance**	Adjustment Cleaning, disinfection Dismantling/ removal of parts, components, devices of the machine Housekeeping Isolation and energy dissipation Lubrication Replacement of tools Replacement of worn parts Resetting Restoring fluid levels

		Verification of parts, components, devices of the machine
6	**Fault finding/ Troubleshooting**	Adjustments Dismantling/ removal of parts, components, devices of the machine Faultfinding Isolation and energy dissipation Recovering from control and protective devices failure Recovering from jam Repairing Replacement of parts, components, devices of the machine Rescue of trapped persons Resetting Verification of parts, components, devices of the machine
7	**Decommissioning** **Dismantling**	Disconnection and energy dissipation Dismantling/ removal of parts, components, devices of the machine Lifting Loading Packing Transportation Unloading

No	Type or group	Orgin	Potential consequences	ISO12100-1	ISO 12100-2		
				Terms & definitions	Inherently safe design measures	Safeguarding and complementary protective measures	Info. for use
1	**Mechanical hazards**	Acceleration, decleration	Being run over	4,2,1	4,2,1	5,1	6,1
		Angular parts	Being thrown	4,2,2	4,2,2	5,2	6,3
		Approach of a moving element to fixed part	Chrushing	4,1	4,3 a	5,3	6,4
		Cutting parts	Cutting or severing		4,3 b	5,5,2	
		Elastic elements	Drawing in or trapping		4,6	5,5,4	
		Falling objects	Entanglement		4,10	5,5,5	
		Gravity	Friction or abrasion			5,5,6	
		Height from the ground	Impact				
		High pressure	Injection				
		Machinery mobility	Shearing				
		Moving elements	Shipping, tripping and falling				
		Rotating elements	Stabbing or puncture				
		Rough, slippery surface	Suffocation				
		Sharp edges					
		Stability					
		Vacuum					
2	**Electrical hazards**	Arc		4,3	4,9	5,2	6,4
		Electromagnetic phenomena	Burn			5,3,2	6,5
		Electrostatic pheomena	Chemical effects			5,5,4	
		Live parts	Effects on medical implants				
		Not enough distance to live parts under high voltage	Electrocution				
		Overload	Falling, being thrown				

		Parts which have become live under fault conditions	Fire				
		Short cicuit	Projection of molten particles				
		Thermal radiation	Shock				
3	**Thermal hazards**	Explosion	Burn	4,4	4,4 b 4,8,4	5,2,7 5,3,2,1 5,4,5	
		Flame	Dehydration				
		Objects or materials with a high or low temperature	Discomfort				
		Radiation from heat sources	Frostbite				
			Injuries by radiation of heat sources				
			Scald				
4	**Noice hazards**	Cavitation phenomena	Discomfort	4,5	4,2,2 4,3 c 4,4 4,8,4	5,1 5,3,2,1 5,4,2	6,3 6,5,1 c
		Exhausting system	Loss of awareness				
		Gas leaking at high speed	Loss of balance				
		Manufacturing process	Permanent hearing loss				
		Moving parts	Stress				
		Scraping Surfaces	Tinnitus				
		Unbalanced rotating parts	Tiredness				
		Whistling pneumatics	Any other as a consequence of an interface with speech communication or with acoustic signals				
		Worn parts					
5	**Vibration hazards**	Cavitation phenomena	Discomfort	4,6	4,2,2 4,3,c 4,8,4	5,3,2,1 5,4,3	6,5,1 c
		Misalignment of moving parts	Low-back morbidity				
		Mobile equipment	Neurogical disorder				
		Scraping surfaces	Osteo-articular disorder				
		Unbalanced rotating parts	Trauma of the spine				

		Vibrating equipment	Vascular disorder				
		Worn parts					
6	**Radiation hazards**	Ionising radiation source	Burn	4,7	4,2,2	5,3,2,1	6,5,1 c
		Low frequency electromagnetic radiation	Damage to eyes and skin		4,3 c	5,4,5	
		Optical radiation (Infrared, visible and ultra violet), including laser	Effects on reproductive capability				
		Radio frequency electromagnetic radiation	Generic mutation				
			Headache, insomnia				
7	**Material/ Substance hazards**	Aerosol	Breathing difficulties, suffoation	4,8	4,2,2	5,1	6,5,1 c
		Biological and microbiological (viral or bacterial) agent	Cancer		4,3 b	5,3,2,1	6,5,1 g
		Combustible	Corrosion		4,3 c	5,4,4	
		Dust	Effects on reproductive capability		4,4 a		
		Explosive	on reproductive capability		4,4 b		
		Fibre	Explosion				
		Flammable	Fire				
		Fluid	Infection				
		Fume	Mutation				
		Gas	Poisoning				
		Mist	Sensitization				
		Oxidizer					
8	**Ergonomic hazards**	Access	Discomfort	4,9	4,2,1	5,2	
		Design or location of indicators and visual display units	Fatigue		4,7	5,3,2,1	
		Design, location or identification of control devices	Musculoskeletal disorder		4,8		
		Effort	Stress		4,11,8		
		Flicker, dazzling, shadow, stroboscopic effect	Any other as a consequence of human error				
		Local lighting					

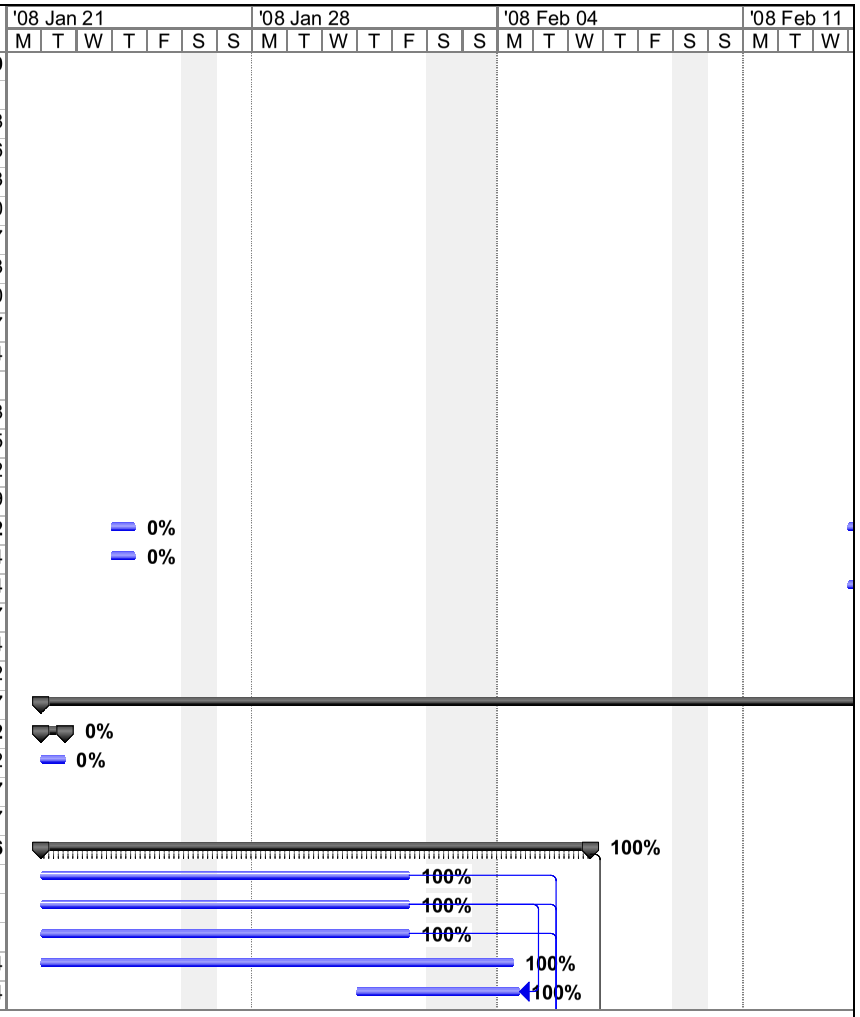
		Mental overload/underload					
		Posture					
		Repetitive activity					
		Visibility					
9	**Hazards associated with environment in which the machine is used**	Dust and fog	Burn	4,12	4,6 4,11,11	5,2,1	6,5,1 b
		Electromagnetic disturbances	Slight disease				
		Lightning	Slipping, falling				
		Moisture	Suffocation				
		Pollution	Any other as a consequence of the effect caused by the sources of the hazards on the machine or parts of the machine				
		Snow					
		Temperature					
		Water					
		Wind					
		Lack of oxygen					
10	**Combination of hazards**	E.g. repetitive activity+ effort +high environmental temperature	E.g. dehydration, loss of awareness, heat stroke	4,11			

APPENDIX I

PROJECT MEDTECH PLANNING & SCHEDULES

MedTech – MF2003
2008-05-13

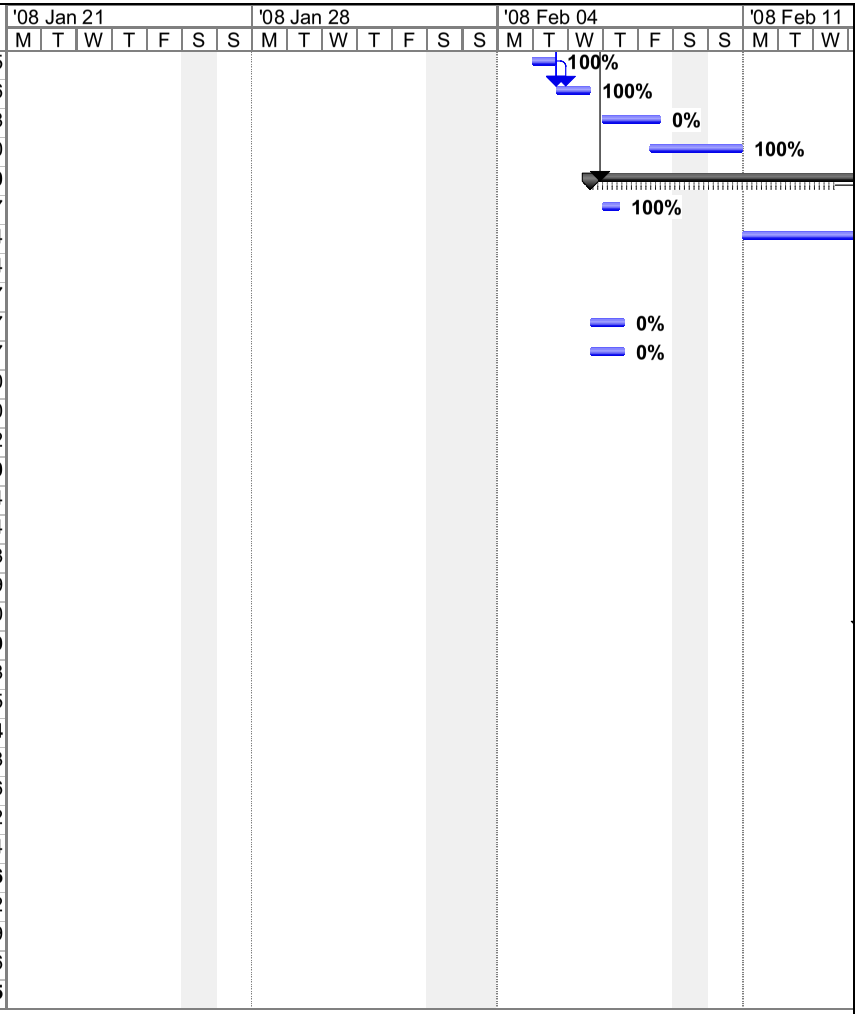
ID	Task Name	Duration	Start	Finish
1	**Telemöte Anders**	**73,25 days**	**Thu 08-02-21**	**Thu 08-05-29**
2	Telemöte Anders 5	0 days	Thu 08-02-21	Thu 08-02-21
3	Telemöte Anders 6	0 days	Thu 08-02-28	Thu 08-02-28
4	Telemöte Anders 7	0 days	Thu 08-03-06	Thu 08-03-06
5	Telemöte Anders 8	0 days	Thu 08-03-13	Thu 08-03-13
6	Telemöte Anders 9	0 days	Thu 08-03-20	Thu 08-03-20
7	Telemöte Anders 10	0 days	Thu 08-03-27	Thu 08-03-27
8	Telemöte Anders 11	0 days	Thu 08-04-03	Thu 08-04-03
9	Telemöte Anders 12	0 days	Thu 08-04-10	Thu 08-04-10
10	Telemöte Anders 13	0 days	Thu 08-04-17	Thu 08-04-17
11	Telemöte Anders 14	0 days	Thu 08-04-24	Thu 08-04-24
12	Telemöte Anders 15	0 days	Thu 08-05-01	Thu 08-05-01
13	Telemöte Anders 16	0 days	Thu 08-05-08	Thu 08-05-08
14	Telemöte Anders 17	0 days	Thu 08-05-15	Thu 08-05-15
15	Telemöte Anders 18	0 days	Thu 08-05-22	Thu 08-05-22
16	Telemöte Anders 19	0 days	Thu 08-05-29	Thu 08-05-29
17	**Månadsmöte**	**92,19 days**	**Thu 08-01-24**	**Thu 08-05-22**
18	1	1 day	Thu 08-01-24	Thu 08-01-24
19	2	2 hrs	Thu 08-02-14	Thu 08-02-14
20	3	1 day	Thu 08-03-27	Thu 08-03-27
21	4	1 day	Thu 08-04-24	Thu 08-04-24
22	5	1 day	Thu 08-05-22	Thu 08-05-22
23	**Inköp**	**6,81 days?**	**Tue 08-01-22**	**Thu 08-04-17**
24	**Mekanik**	**1 day?**	**Tue 08-01-22**	**Tue 08-01-22**
25	Verkstad	1 day?	Tue 08-01-22	Tue 08-01-22
26	**Elektronik**	**16 days**	**Thu 08-03-27**	**Thu 08-04-17**
27	Nätagg	16 days	Thu 08-03-27	Thu 08-04-17
28	**Fas 0**	**13,63 days**	**Tue 08-01-22**	**Wed 08-02-06**
29	Projektdefinition klar	10 days	Tue 08-01-22	Fri 08-02-01
30	Produktspecifikation klar	10 days	Tue 08-01-22	Fri 08-02-01
31	Förstudie/bakgrund	10 days	Tue 08-01-22	Fri 08-02-01
32	Val av utvecklingsplatform	11 days	Tue 08-01-22	Mon 08-02-04
33	Idésammanställning	3 days	Thu 08-01-31	Mon 08-02-04



Project: MedTech Project Plan
Date: Mon 08-06-02

Critical	Baseline	Project Summary
Critical Split	Baseline Split	External Tasks
Critical Progress	Baseline Milestone	External Milestone
Task	Milestone	Deadline
Split	Summary Progress	
Task Progress	Summary	

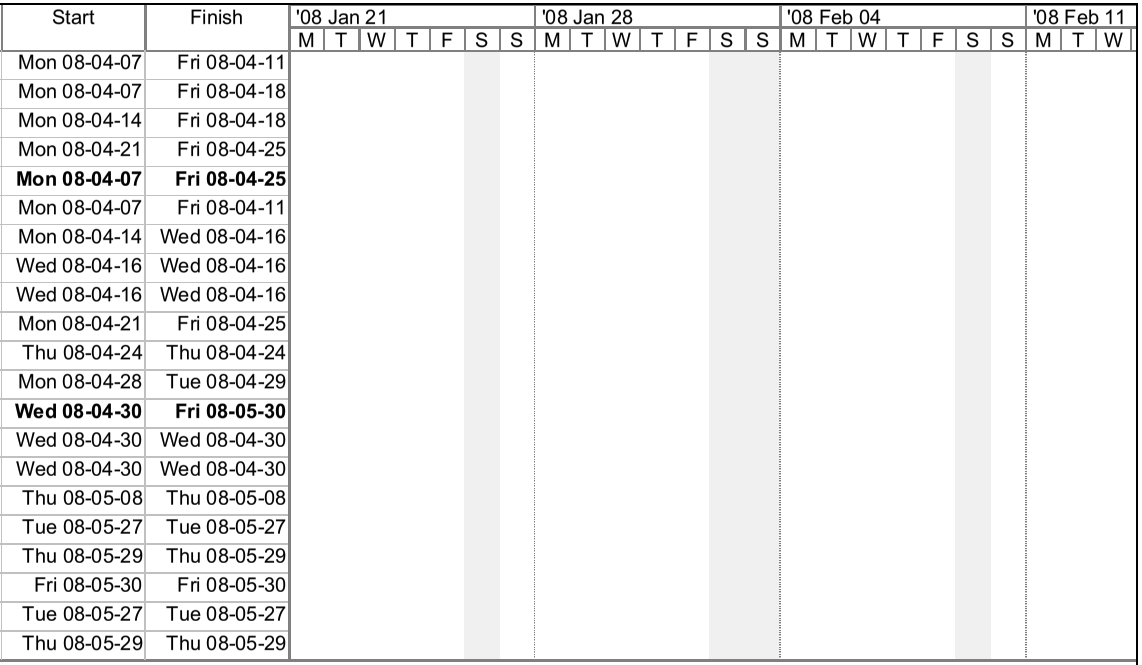
ID	Task Name	Duration	Start	Finish
34	RISK-analys dokumenterad	1 day	Tue 08-02-05	Tue 08-02-05
35	Produktdefinition klar	1 day	Tue 08-02-05	Wed 08-02-06
36	Progressrapport	2 days	Thu 08-02-07	Fri 08-02-08
37	Produktdef godkänd	2 days	Fri 08-02-08	Sun 08-02-10
38	**Fas 1**	**25,5 days?**	**Wed 08-02-06**	**Mon 08-03-10**
39	Beslut om vilken/vilka prototyper som går vidare.	0,5 days	Thu 08-02-07	Thu 08-02-07
40	Bygga prototyper - Pappersversioner	4 days	Mon 08-02-11	Thu 08-02-14
41	Beslut om vilken prototyp som går vidare	0 days	Thu 08-02-14	Thu 08-02-14
42	Arbeta med prototyp	16 days	Fri 08-02-15	Fri 08-03-07
43	Liten teknisk rapport	1 day?	Wed 08-02-06	Thu 08-02-07
44	Mekaniska beräkningar	1 day?	Wed 08-02-06	Thu 08-02-07
45	Val av konstruktion och komponenter. (Beställa)	0,5 days	Mon 08-03-10	Mon 08-03-10
46	Dokumentera motiveringarna över val av mekanisk respek	0,5 days	Mon 08-03-10	Mon 08-03-10
47	Progressrapport	2 days	Tue 08-03-11	Wed 08-03-12
48	**Tenta/Lov/Ledighet**	**69,75 days**	**Thu 08-02-28**	**Fri 08-05-30**
49	Tentavecka 1	5 days	Mon 08-03-10	Fri 08-03-14
50	Påsk	4 days	Mon 08-03-17	Mon 08-03-24
51	Laban Ledig	2 days	Thu 08-04-17	Fri 08-04-18
52	Christian Ledig	2 days	Thu 08-02-28	Fri 08-02-29
53	Tentavecka 2	5 days	Mon 08-05-26	Fri 08-05-30
54	**Fas 2**	**4,13 days?**	**Mon 08-03-31**	**Tue 08-04-29**
55	All beställd hårdvara på plats	1 day	Fri 08-04-18	Fri 08-04-18
56	Integration av Mekanik- Elektronik	21 days	Mon 08-03-31	Fri 08-04-25
57	**Mekanikritningar färdiga**	**13,81 days**	**Tue 08-04-08**	**Thu 08-04-24**
58	Delritningar klara - Väggar och botten	0 days	Tue 08-04-08	Tue 08-04-08
59	Delritningar klara - Drivarm och plattarm	0 days	Wed 08-04-16	Wed 08-04-16
60	Delritningar klara - Armstödet + Elektroniklåda + Bord	0 days	Tue 08-04-22	Tue 08-04-22
61	Samtliga ritningar klara	0 days	Thu 08-04-24	Thu 08-04-24
62	**Elektronikritningar färdiga**	**9,56 days**	**Wed 08-04-02**	**Wed 08-04-16**
63	Layout på PCB klar	0 days	Wed 08-04-02	Wed 08-04-02
64	Etsning + montering	0 days	Wed 08-04-09	Wed 08-04-09
65	Kretskorten fungerar	0 days	Wed 08-04-16	Wed 08-04-16
66	**Mjukvara**	**5,94 days?**	**Mon 08-04-07**	**Fri 08-04-25**



Project: MedTech Project Plan
Date: Mon 08-06-02

Critical	Baseline	Project Summary
Critical Split	Baseline Split	External Tasks
Critical Progress	Baseline Milestone	External Milestone
Task	Milestone	Deadline
Split	Summary Progress	
Task Progress	Summary	

ID	Task Name	Duration	Start	Finish
67	Fungerande seriell överföring	5 days	Mon 08-04-07	Fri 08-04-11
68	Förundersökning av GUI klar	10,63 days	Mon 08-04-07	Fri 08-04-18
69	Grundläggande funktioner fungerande (graf, knappar	5,31 days?	Mon 08-04-14	Fri 08-04-18
70	Fungerande GUI färdigställs	5,31 days?	Mon 08-04-21	Fri 08-04-25
71	**AVR32-programmering**	**5,94 days?**	**Mon 08-04-07**	**Fri 08-04-25**
72	Kommunikation till dator	5,31 days?	Mon 08-04-07	Fri 08-04-11
73	Tidsinterrupt	3,19 days?	Mon 08-04-14	Wed 08-04-16
74	AD-omvandling av positionssignal	1,06 days?	Wed 08-04-16	Wed 08-04-16
75	Reglerberäkning	1,06 days?	Wed 08-04-16	Wed 08-04-16
76	Färdigställd AVR-programmering	5,31 days?	Mon 08-04-21	Fri 08-04-25
77	Design av produkt klar	1 day	Thu 08-04-24	Thu 08-04-24
78	Progressrapport	2 days	Mon 08-04-28	Tue 08-04-29
79	**Fas 3**	**24,38 days**	**Wed 08-04-30**	**Fri 08-05-30**
80	Acceptans-Testspecifikation tas fram utifrån krav och prod	1 day	Wed 08-04-30	Wed 08-04-30
81	Användargränssnitt bestäms	1 day	Wed 08-04-30	Wed 08-04-30
82	Integrationstest PC-produkt	1 day	Thu 08-05-08	Thu 08-05-08
83	Acceptanstest godkända	1 day	Tue 08-05-27	Tue 08-05-27
84	Projektbokslut	1 day	Thu 08-05-29	Thu 08-05-29
85	Projektrapport	1 day	Fri 08-05-30	Fri 08-05-30
86	Intern presentation för uppdragsgivare / slutfest för gruppe	0 days	Tue 08-05-27	Tue 08-05-27
87	Presentation	0 days	Thu 08-05-29	Thu 08-05-29



Project: MedTech Project Plan
Date: Mon 08-06-02

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External Tasks
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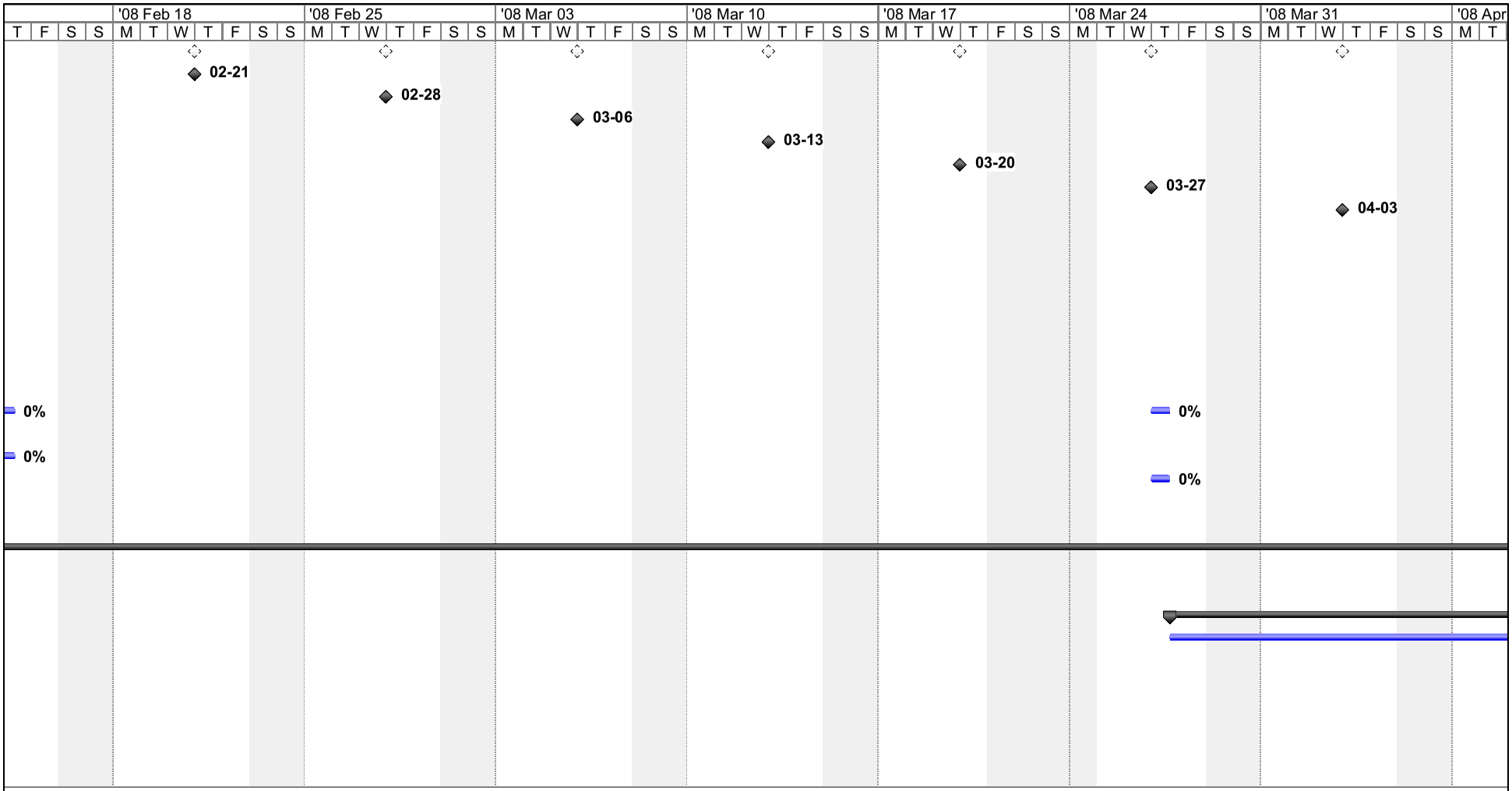
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Project: MedTech Project Plan
Date: Mon 08-06-02

Critical	Baseline	Project Summary
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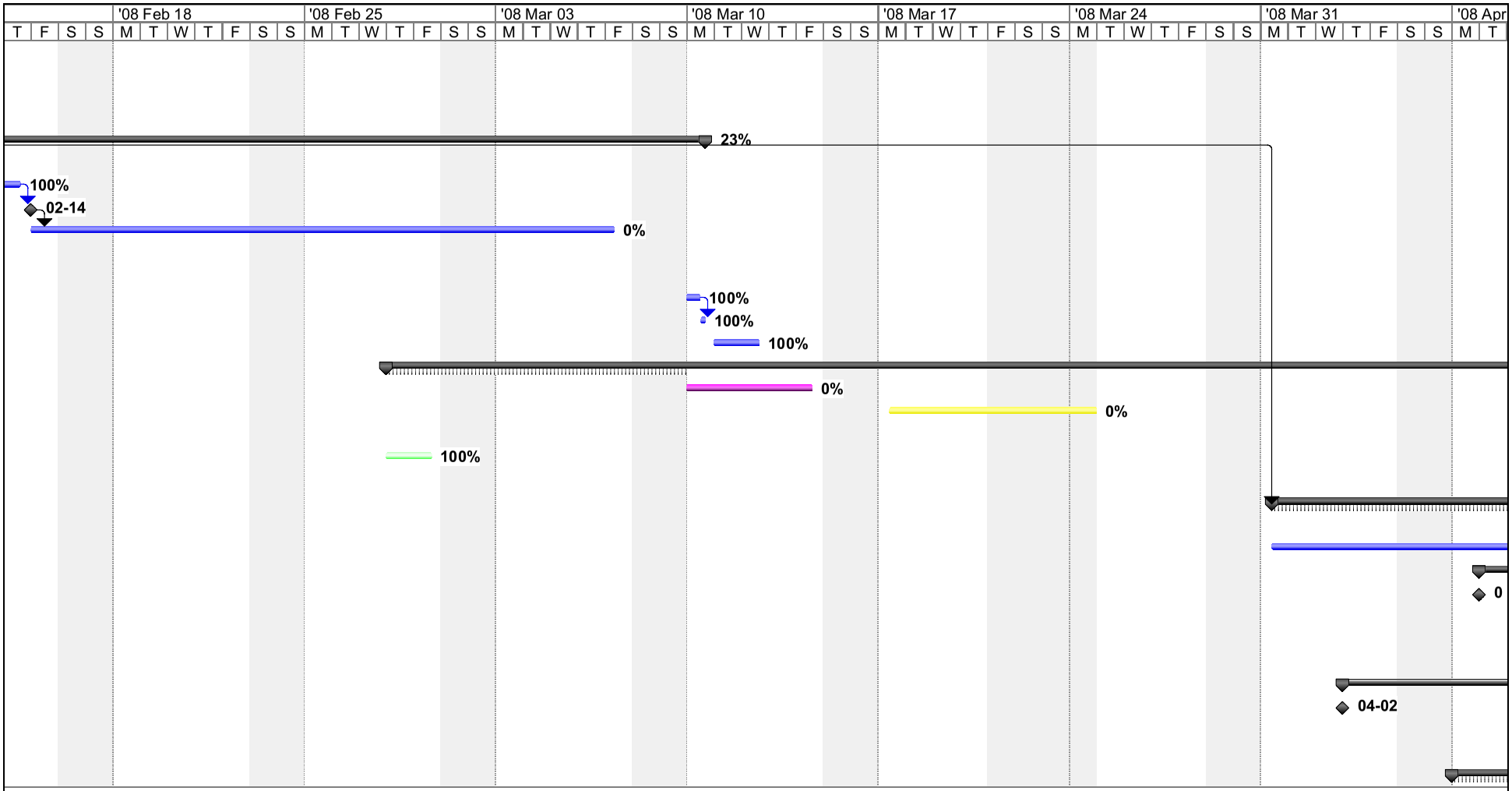
Critical Progress	Baseline Milestone	External Milestone
Task	Milestone	Deadline
Split	Summary Progress	
Task Progress	Summary	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Project: MedTech Project Plan
Date: Mon 08-06-02

Critical	Baseline	Project Summary
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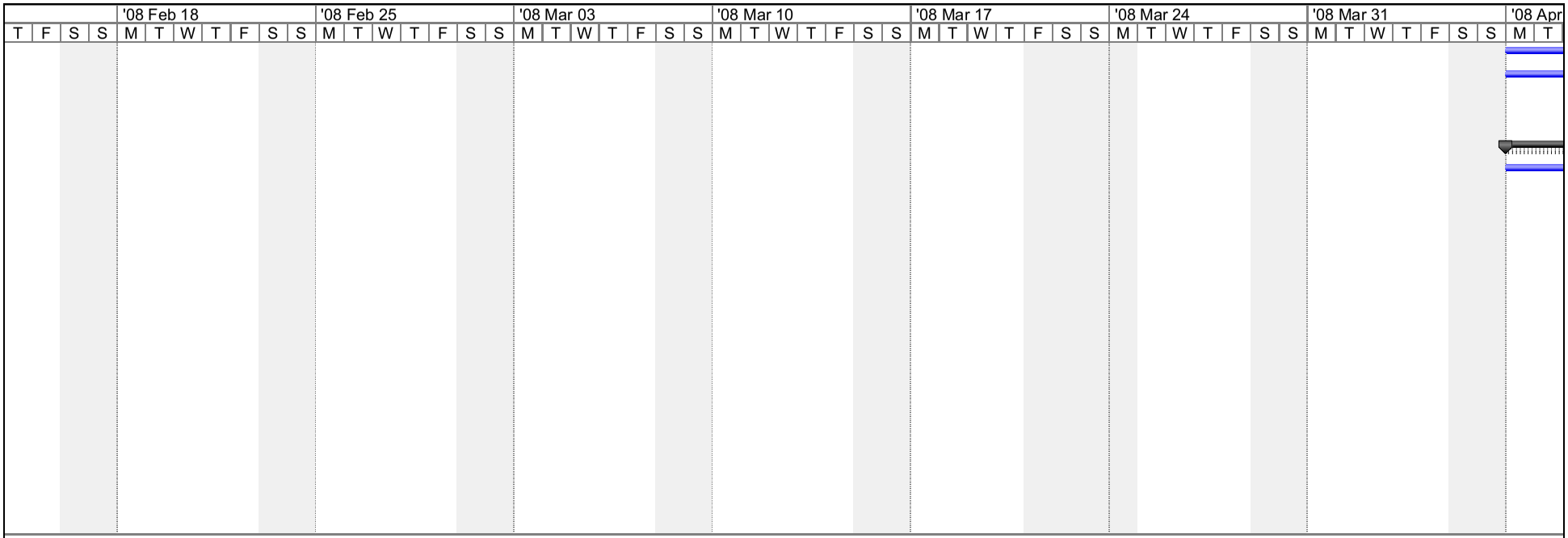
Critical Progress	Baseline Milestone	External Milestone
Task	Milestone	Deadline
Split	Summary Progress	
Task Progress	Summary	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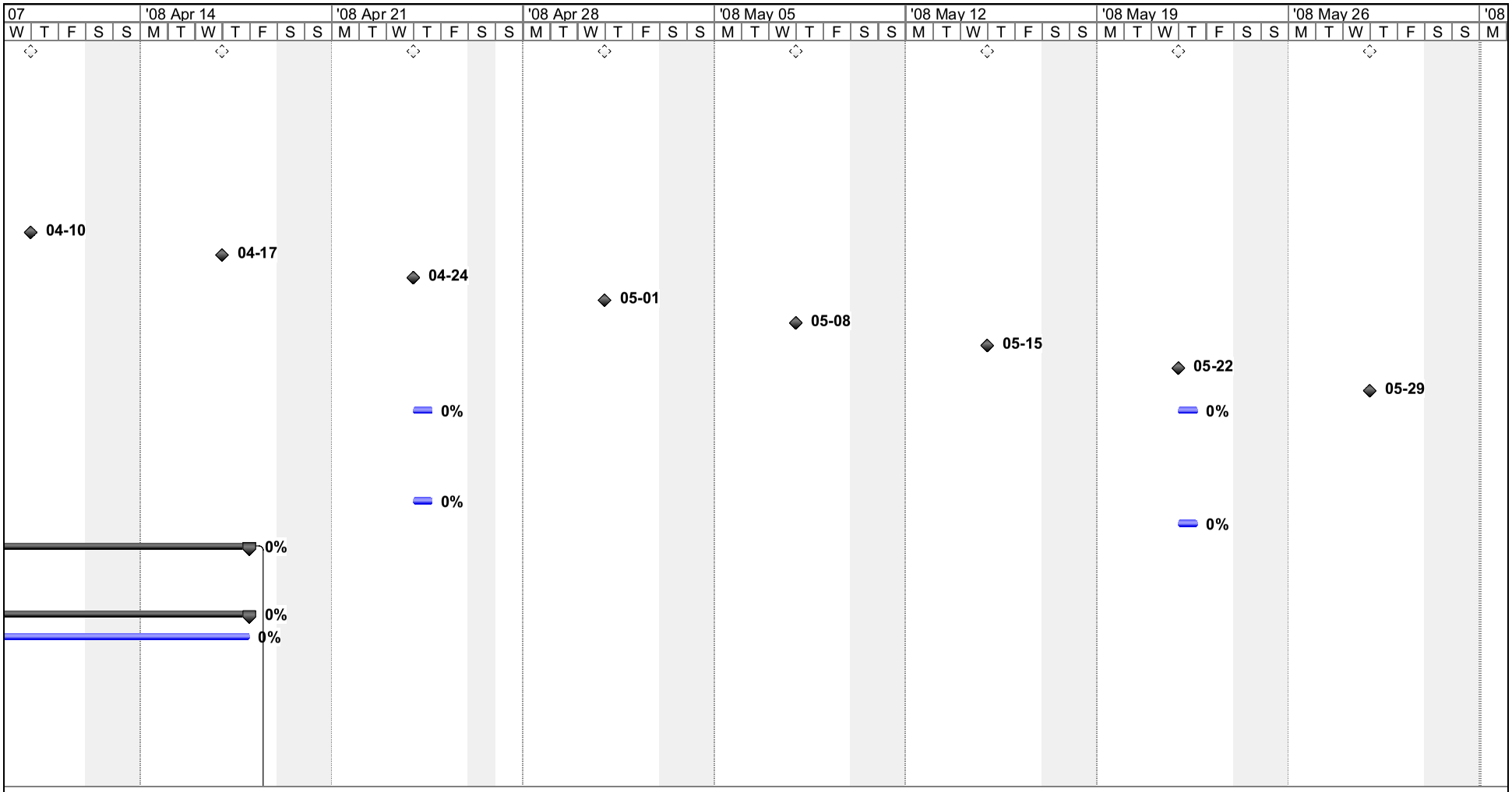
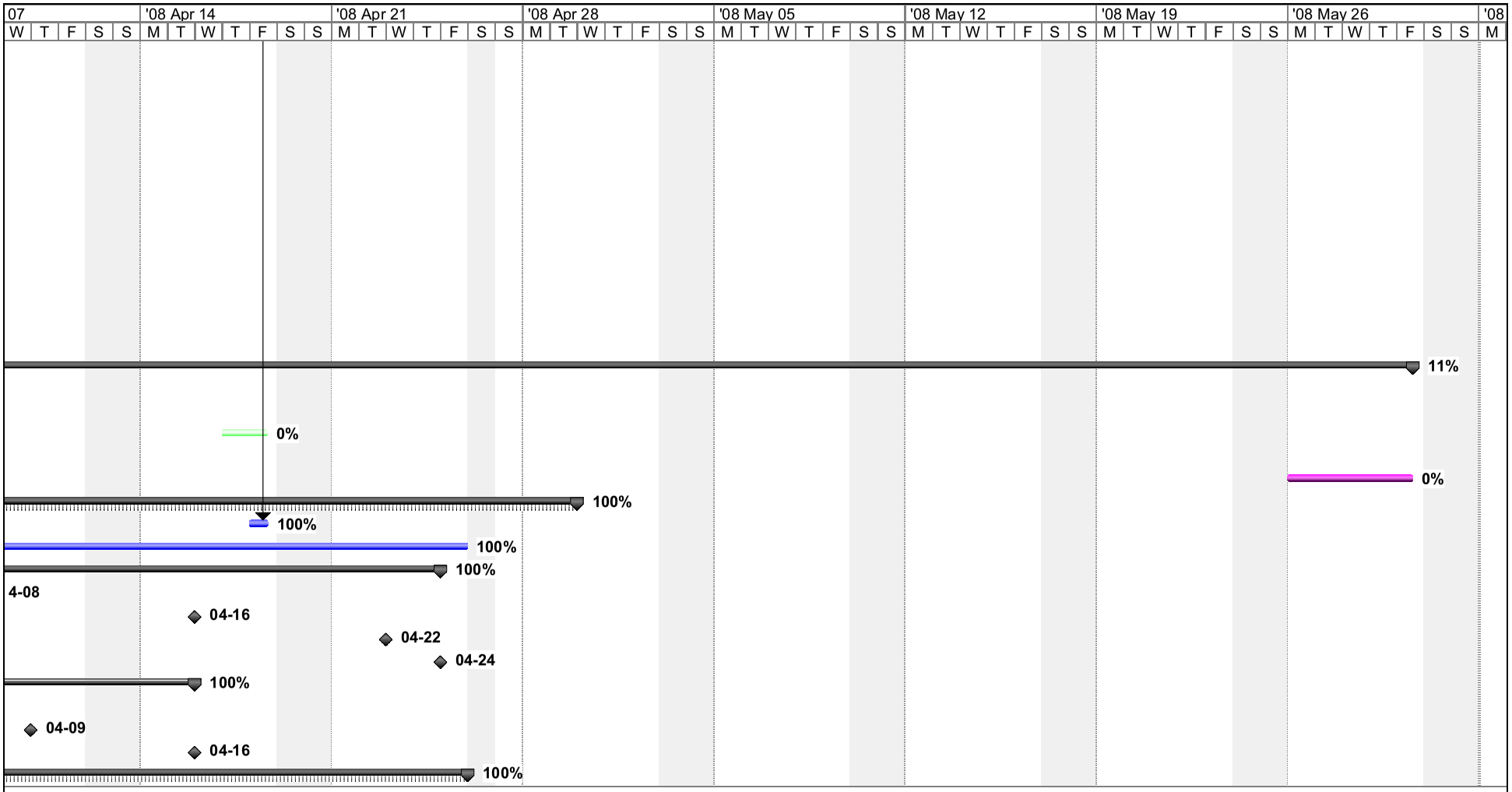
Project: MedTech Project Plan
Date: Mon 08-06-02

Critical		Baseline		Project Summary	
Critical Split		Baseline Split		External Tasks	
Critical Progress		Baseline Milestone	◇	External Milestone	◇
Task		Milestone	◆	Deadline	⇩
Split		Summary Progress			
Task Progress		Summary			



Project: MedTech Project Plan
Date: Mon 08-06-02

Critical		Baseline		Project Summary	
Critical Split		Baseline Split		External Tasks	
Critical Progress		Baseline Milestone	◇	External Milestone	◆
Task		Milestone	◆	Deadline	⇩
Split		Summary Progress			
Task Progress		Summary			



Project: MedTech Project Plan
Date: Mon 08-06-02

Critical	Baseline	Project Summary
Critical Split	Baseline Split	External Tasks
Critical Progress	Baseline Milestone	External Milestone
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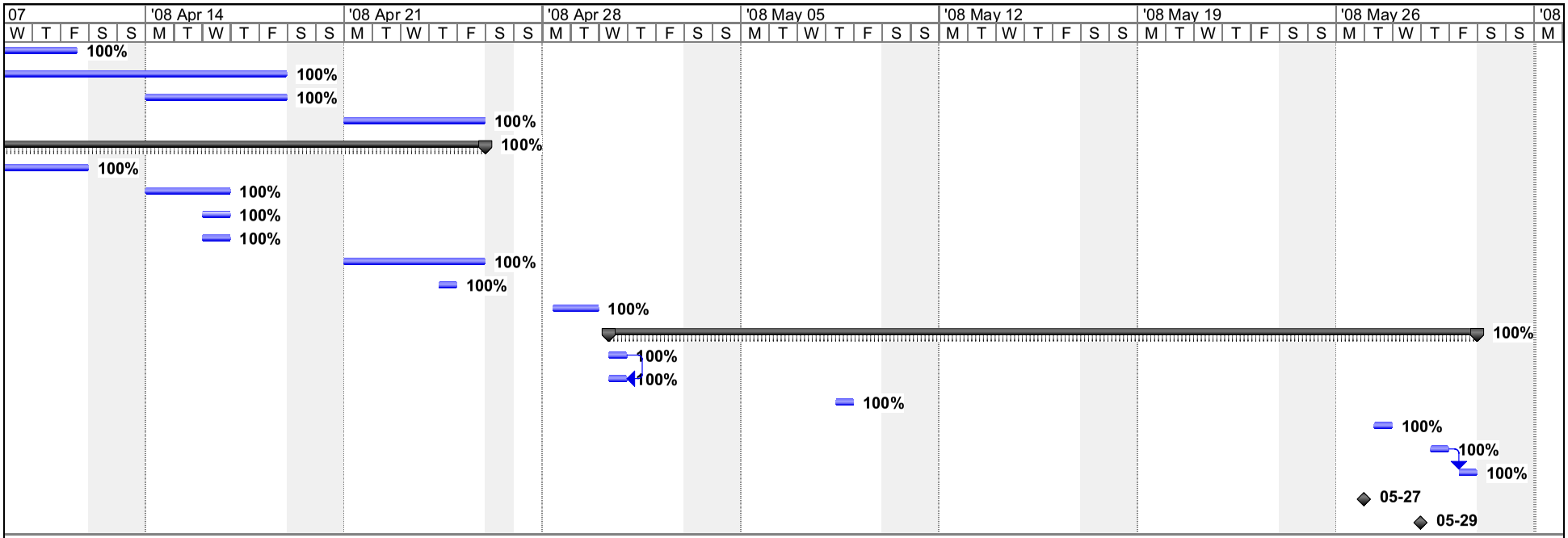

Project: MedTech Project Plan
Date: Mon 08-06-02

Critical		Baseline		Project Summary	
Critical Split		Baseline Split		External Tasks	
Critical Progress		Baseline Milestone	◇	External Milestone	◆
Task		Milestone	◆	Deadline	⇩
Split		Summary Progress			
Task Progress		Summary			

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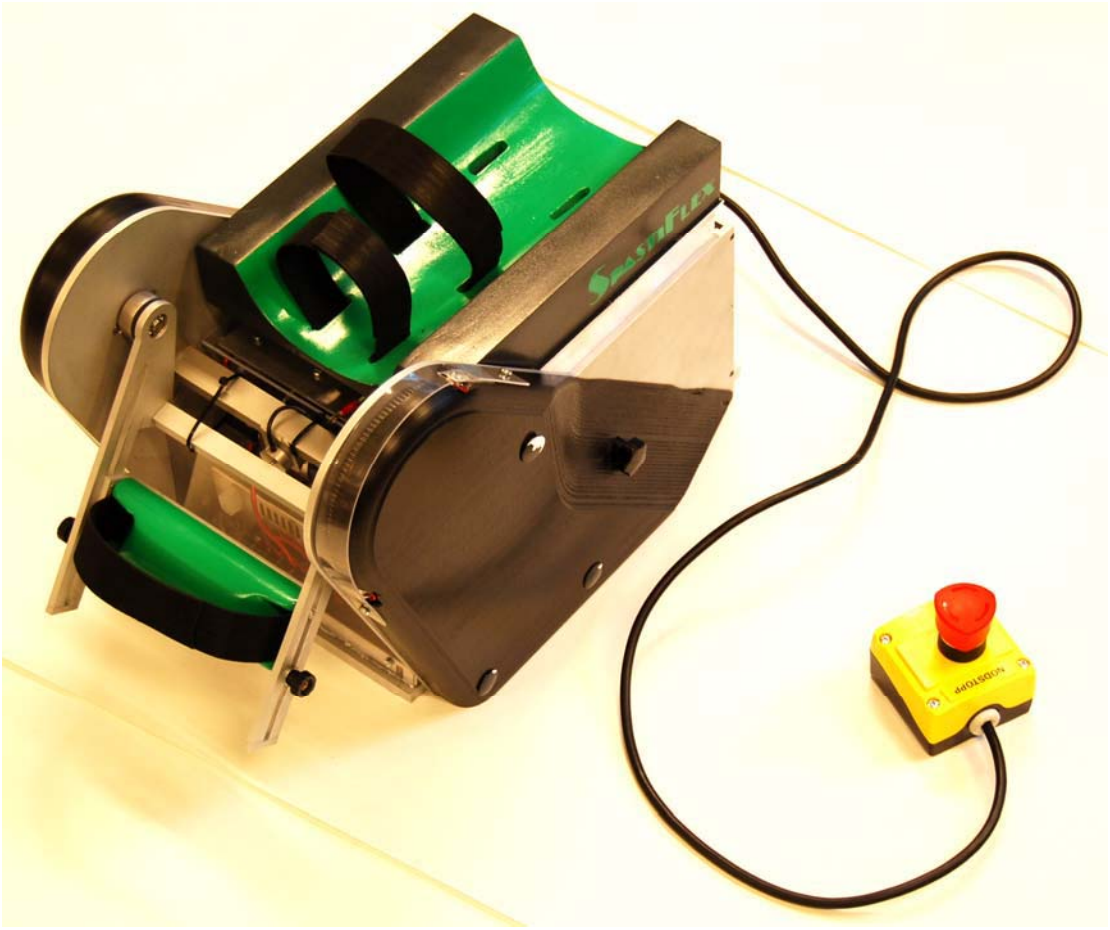
APPENDIX J

USER MANUAL

MedTech – MF2003
2008-05-13

SpastiFlex
MEDICAL DIAGNOSTICS DEVICE

User Manual
&
Assembly Instructions



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Introduction

Welcome to the world of SpastiFlex, a new way of making diagnosis.

This is the user manual for a prototype named SpastiFlex. This prototype was made by a student group at the Royal Institute of Technology in Stockholm, Sweden, during the spring of 2008. With the Karolinska Institute as assigner a prototype for making diagnosis on patients with spasticity was to be developed.

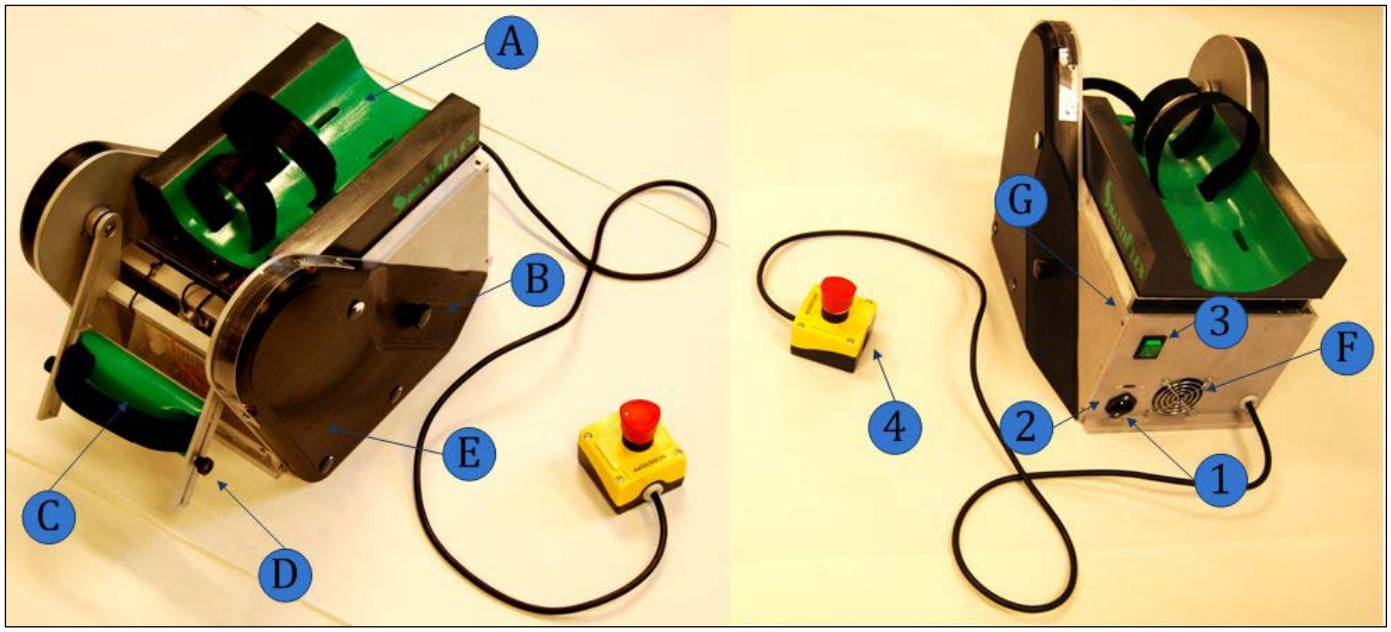
If the reader wants deeper understanding and more information about any part of the software or mechanics, we recommend reading that part of the project report. That should cover all of the development that has been done.

Safety – read this first

When using the SpastiFlex, there are a number of safety aspects that any patient or operator should be aware of. Read through all of these points before using the SpastiFlex.

1. The SpastiFlex can only be used in countries with the mains set to 230V AC 50Hz.
2. The SpastiFlex can be carried by one person but it must be lifted in the bottom plate. It can NOT be lifted in the plastic parts or the armholder etc.
3. When placing the SpastiFlex on a surface, ensure that the surface is flat and can withstand the weight of the SpastiFlex.
4. When using the SpastiFlex, make sure that air can circulate freely around the SpastiFlex. Especially around the fan at the rear plate.
5. Before using the SpastiFlex, ensure that it is rigidly mounted to the table using clamps or screws.
6. When not using the SpastiFlex, make sure that the power switch is turned off.
7. When leaving the SpastiFlex unused for longer periods of time, disconnect the mains.
8. During lightning storms, disconnect the SpastiFlex from the mains.
9. Do not keep vessels with water nearby the SpastiFlex. Spilling water into the SpastiFlex can result in an electric shock. If water has come in contact with the SpastiFlex, directly disconnect it from the mains at the wall socket outlet and do not operate it.
10. A patient strapped to the SpastiFlex can not be left alone, an operator must always be nearby ready with the emergency stop.
11. When using the SpastiFlex, always make sure that the emergency stop is easily reachable for the operator.
12. Before doing any maintenance or adjustments to this prototype, make sure that it is switched off and disconnected from the mains.
13. When cleaning the SpastiFlex, make sure that it is switched off and disconnected from the mains.

1. Parts and connectors



1. Connector for main power cord. Only 240V AC 50Hz allowed.
2. Connector for USB to computer. Insert the plug with the USB-logotype facing upwards.
3. Power switch. When the switch is light, the SpastiFlex is turned on.
4. Emergency stop and flexible cord. This should always be reachable for the operator.

A. Arm holder
B. Screws for adjustment of arm holder height
C. Hand pad
D. Screws for adjustment of distance between hand pad and center of rotation
E. Plastic sidewalls for shielding
F. Fan outlet
G. Electronics box

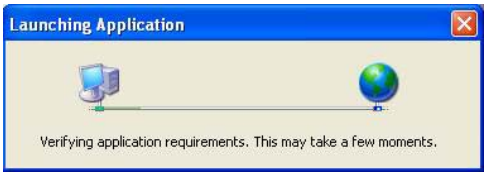
2. SpastiFlex Software

This section covers the procedures for installing/uninstalling the SpastiFlex software and also instructions for the operator that will use it. The software comes in a neat package with everything included, just to install and run. It requires the .NET-framework but if that is not installed on the computer the installer will download and install it.

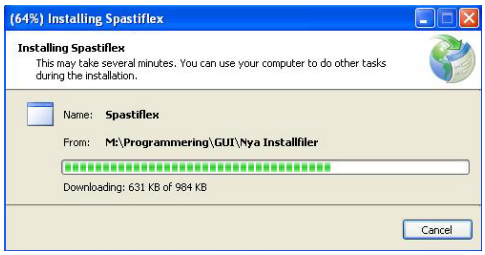
2.1. Installing the SpastiFlex software

This is a step by step instruction for installing the SpastiFlex software on a PC computer with Microsoft Windows XP.

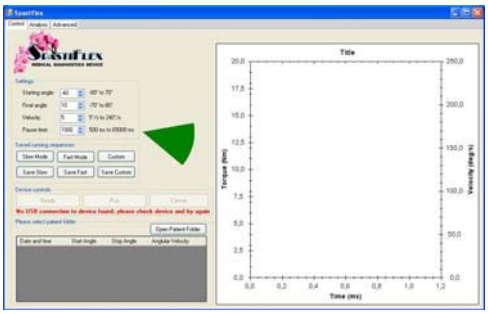
1.
Locate and execute the file setup.exe.



2.
The installer will automatically check whether the computer meets the requirements or not. For example, if .NET-framework is not installed on the computer, the installer will do it for you.


(64%) Installing Spastiflex
Installing Spastiflex
This may take several minutes. You can use your computer to do other tasks during the installation.
Name: Spastiflex
From: M:\Programmering\GUI\Nya Installfiler
Downloading: 631 KB of 984 KB
Cancel

3.
After that the installer for the SpastiFlex software will start and install all necessary files. You do not have to make any settings such as install path.



4.
When the installation has finished, the SpastiFlex GUI will appear on the screen and it is ready to use.

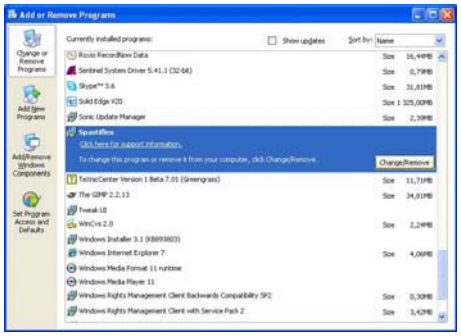
5.
The software can later be started by opening the Start-menu and under “All programs” locating KTH -> SpastiFlex.

2.2. Uninstalling the SpastiFlex software

Uninstalling the SpastiFlex software is easy. Just follow these steps.

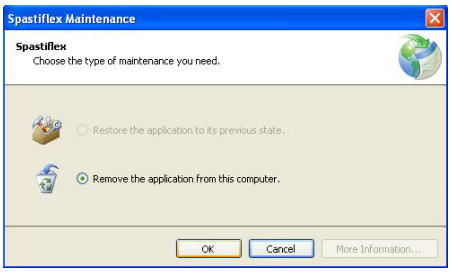
1.

Open the Start-menu and click on “Control Panel”. Choose “Add or remove programs”.



2.

SpastiFlex can be found in the list of installed programs that appear. Click on the “Change/Remove”-button.



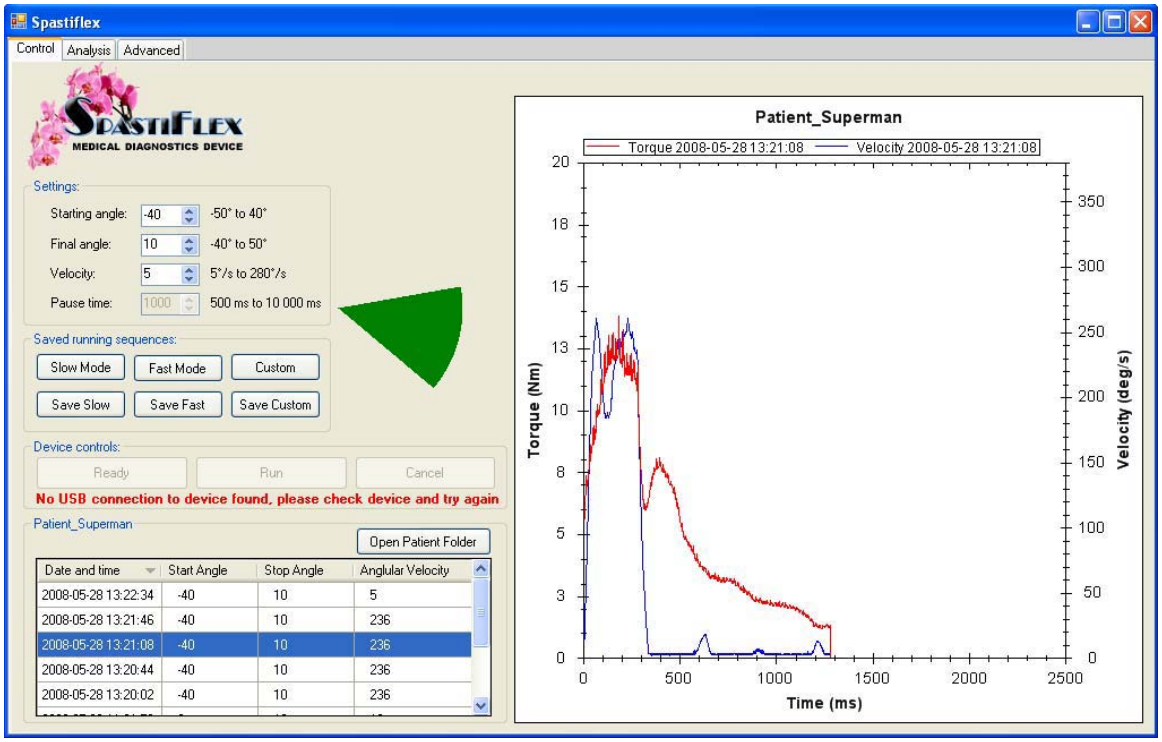
3.

Choose “OK” and the SpastiFlex software will be removed from the computer. It can later simply be installed again.

2.3. Using the SpastiFlex software

First of all, make sure that the SpastiFlex is connected to the computer using a high quality USB cable. Start the program found in "Start menu -> All programs -> KTH -> Spastiflex". You will see three tabs at the top of the program, these are explained below.

2.2.1. Running the SpastiFlex



1. In the Control tab, choose or create a patient folder (should be unique for each patient) by clicking "Open patient folder". Any previous analysis made with that patient will appear in the list at the bottom left corner of the window.

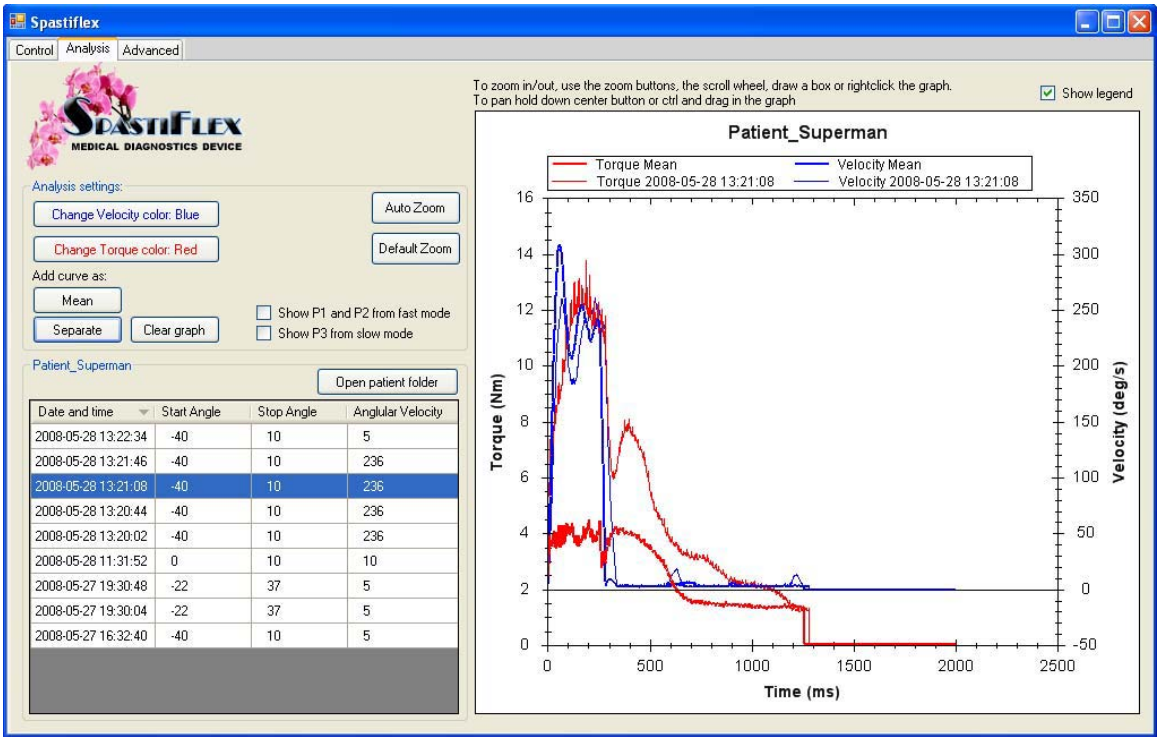
2. Set angles, velocity and pause time for the run by inserting the values in the corresponding boxes or, to set default values, click "Slow Mode", "Fast Mode" or "Custom". To save modes suitable for a specific patient click "Save Slow", "Save Fast" or "Save Custom". These values will be saved in the patient folder and will be loaded the next time you push "Slow Mode", "Fast Mode" or "Custom" with that patient folder selected.

3. Check the values and the visualization of the angles.

4. Press "Ready". Spastiflex will slowly go to the starting angle. Press "Cancel" if you want to interrupt the process.

5. Whenever you and the patient are ready to run the analysis, press "Run". If you want to interrupt the run, press "Stop" in the window that appears. A preview of the run will be shown in the graph window.

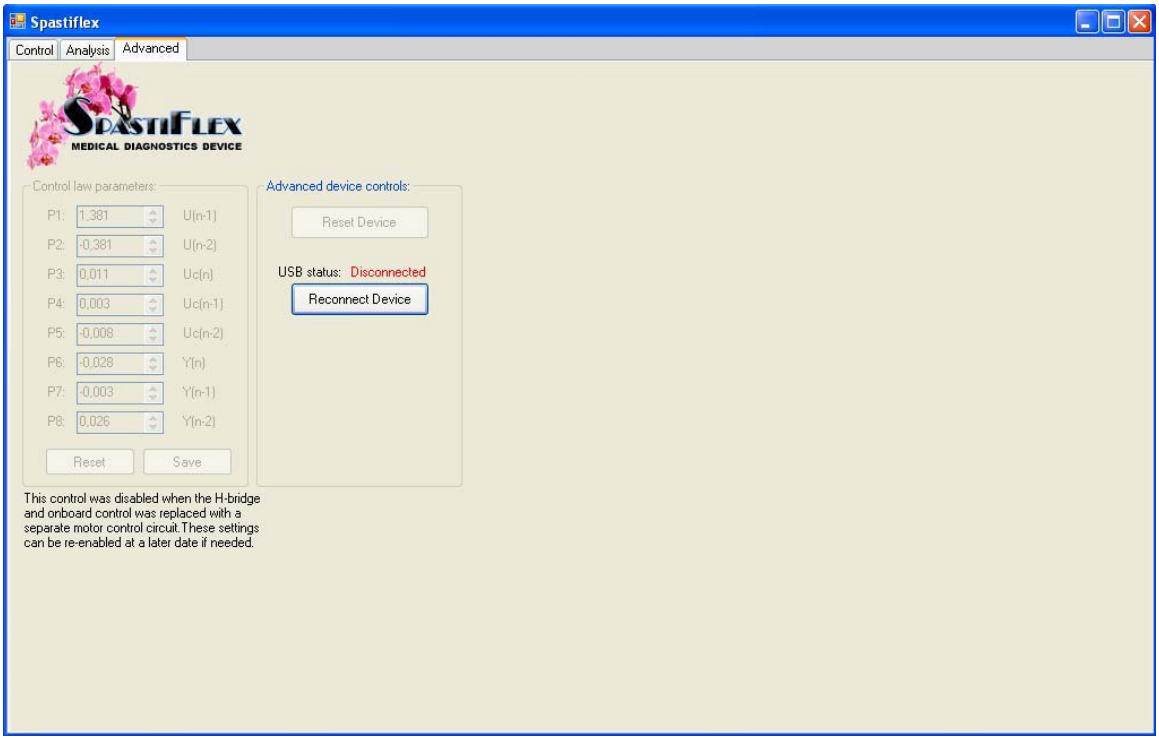
2.2.2. Analyzing the results



In the Analysis tab choose the colors you want for drawing the force and the speed curves and what runs you want to visualize. When you have selected if you want to show the mean value of the runs or each run separately the graphs are shown. You can add curves by repeating the previous selections. The option "Clear graph" clears all the graphs from the graph pane.

- If you want to display P1 and P2, or P3, mark their respective checkboxes.
- To put standard y-axis values, press "Default Zoom".
- To auto scale the axes press "Auto Zoom".
- To zoom in the graph, use the scroll wheel or draw a box.
- To pan in the graph, hold down the center mouse button and drag or hold down Ctrl + left mouse button and drag.
- To undo the last zoom/pan made in the graph right click and choose "Un-Zoom"/"Un-Pan".
- To display the values when you drag the mouse along the curve, right click in the graph and activate the option "Show Point Values". To stop displaying inactivate that option.
- To copy the view to the clipboard, right click in the graph and select "Copy".
- To save the view as an image, right click in the graph and choose "Save Image As…".
- To print the view, right click in the graph and select "Print…".

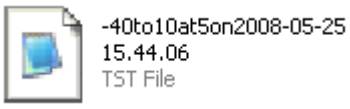
2.2.3. The Advanced-tab



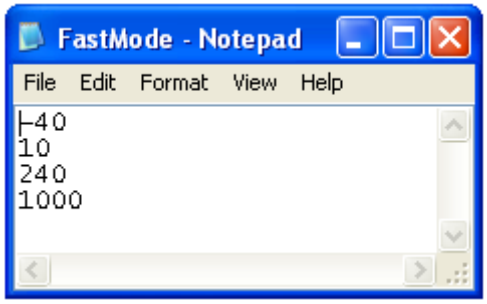
Most of the options under the Advanced-tab are for changing the parameters for the motor controller in the SpastiFlex. This is however not implemented in this prototype but the possibility is there for future improvements. The "Reset Device"-button is not implemented either, the best way to reset the SpastiFlex is to reset its power via the switch.
The only active button under the Advanced-tab today is the button for reconnecting the device. This is used if contact via USB is lost (for example, someone unplugs the cable to the SpastiFlex).

2.2.4. The files (for advanced users)

In the patient folders the runs are saved in the format "<starting angle>to<final angle>at<velocity>on<date><time>.tst"



In each patient folder there are also three files saved with information about the running modes, these are named "CustomMode.txt", "FastMode.txt" and "SlowMode.txt". Only delete these if you want to reset the modes used for that patient to default.
In the program folder there are three files with corresponding names, do NOT delete these, edit them only if you want to change the default saved modes. They are configured as follows:
<Starting angle>
<Final angle>
<Velocity>
<Pause time>



In the program directory there is also a file "Parameters.txt" with parameter values for the motor control. These are not implemented in this prototype.

3. The mechanics of SpastiFlex

Before any operator or user should attempt to do maintenance on the SpastiFlex, cleaning or making adjustments, make sure that everything under "Safety – read this first" is read and understood.

3.1. Cleaning the SpastiFlex

When doing routine cleaning of the SpastiFlex, between patients and when it has been unused for a longer period of time, there are a number of things that are good to know.

1. Before doing any cleaning of the SpastiFlex, make sure that the switch is off and that it is disconnected from the mains.
2. All metal parts can be cleaned with alcohol with no problem
3. The painted surfaces (the arm holder and hand pad) are more sensitive to different chemicals but have been tested with a mix of 70% alcohol and 30% water with no problem.
4. Never use excessive amounts of cleaning solutions on the SpastiFlex; no fluids are allowed inside the SpastiFlex. Severe injuries can occur if fluids enter the electronics box.
5. If any fluid has entered the SpastiFlex, do not connect it to the mains or operate it.

3.2. Assembly and disassembly

This section covers the comprehensive procedure for assembly and disassembly of the SpastiFlex prototype. This is included with the purpose that the future user should be able to make simpler adjustments to the prototype.

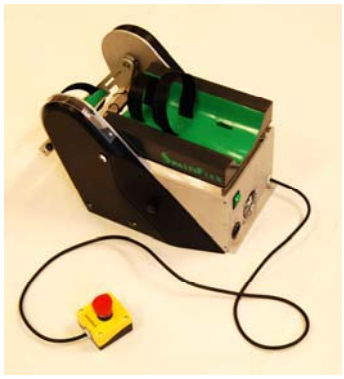
3.2.1. Important – read this first

Since this is a prototype there are some things that anyone attempting to do adjustments to the SpastiFlex should know.

1. All surfaces are sensitive to scratches, especially the painted surfaces such as the arm holder and the hand pad.
2. All threads are easily permanently damaged through tightening the screws too hard. This is especially true for the screws holding the arm holder and the hand pad. Most screws that are holding the metal parts together have simple threads in aluminum making them very sensitive. Unnecessary disassembly should be avoided.
3. No violence should be needed for assembly or disassembly. If something seems stuck, check again for screws holding those parts together. There are no parts that are permanently fastened to each other.
4. The ball bearings are extra sensitive to loads from wrong directions. Be careful when assembling or disassembling the arm for the hand pad.

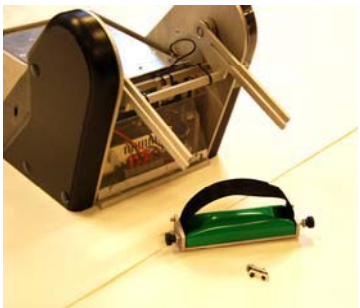
3.2.2. How to assemble/disassemble the SpastiFlex

This instruction is for disassembling the SpastiFlex prototype from a complete prototype to all parts separated except for the electronics that still are attached to the bottom plate. The assembly is the reversal of the disassembly. The only tools necessary for the disassembly are '+'- and '-'-screwdrivers and the following sizes of allen keys: 0.5, 1, 2, 2.5, 3, 4 mm.

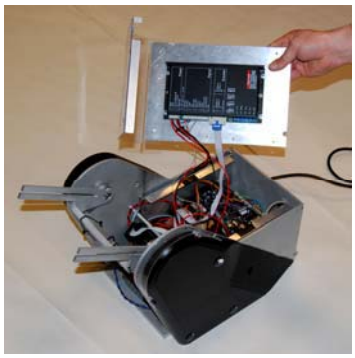


1.
This is what the prototype looks like complete.

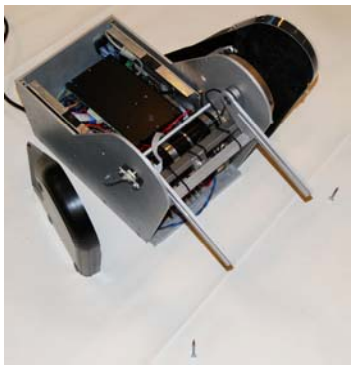
2.
Start with unscrewing the two screws that are for adjusting the height of the arm holder. When these are removed the arm holder can be lifted straight up and removed.



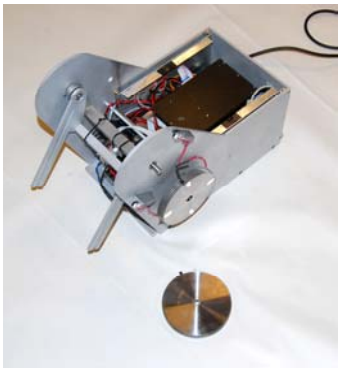
3.
This step is only necessary if you want to make adjustments to the hand pad. Removal of the hand pad is done by removing the two aluminum stops at the end of the handle arm. If nothing is to be done to the hand pad it can be left in its rail.



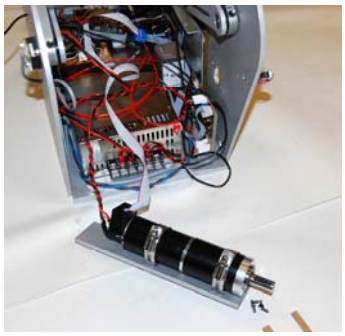
4.
Remove the top of the electronics box. This is done by unscrewing the eight screws visible from above that are placed in two rows along the sides. (Do not unscrew the four screws in between the two rows!) Carefully lift the top and the transparent plastic front plate off the prototype.



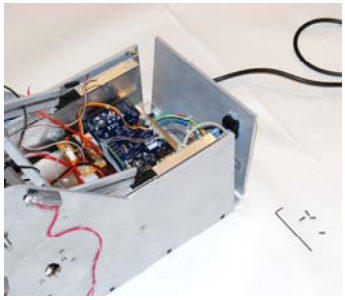
5.
Carefully unscrew the two bigger screws that hold the plastic sides to the aluminum walls. These are reached from the inside of the walls; a short screwdriver is necessary. There are two screws per side, when these are loosened the sides can be lifted off.



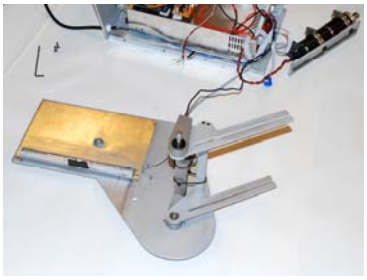
6.
Remove the two gear wheels. Both of these are fastened to the shafts using 3mm allen head screws reached in through the holes in the gear wheels. Loosen the screws and gently pull the gear wheels off the shafts.



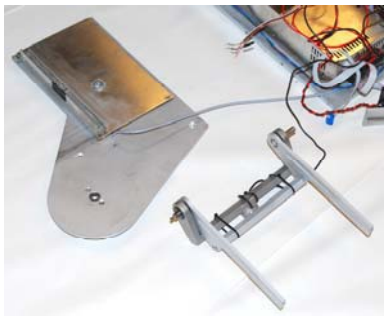
7.
Remove the motor. The motor is primarily held by two screws from the left outer aluminum wall. When these are loosened it will still be held by two metal straps to the motor plate. The motor plate is held to the side walls using two allen head screws per side. Remove these and the motor with the motor plate can be removed from the prototype. The motor can than be removed from the motor plate.



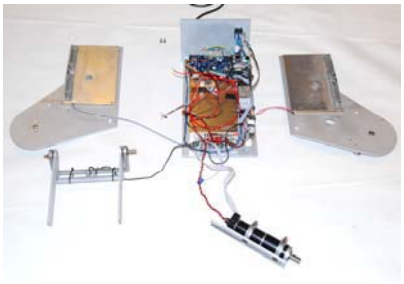
8.
The rear plate is held by three allen head screws per side. When these are removed the plate can be slided backwards. To remove it completely all connectors and wires has to be disconnected.



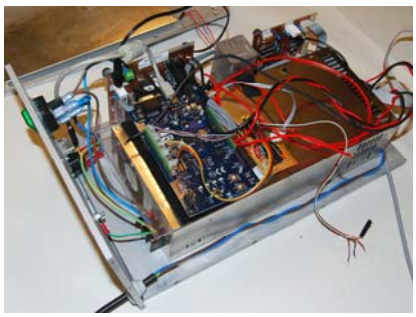
9.
Both sides are fastened to the bottom plate using four allen head screws per side. It is suggested to remove the right side first. Unscrew the four screws and slowly, by holding both the driving arms and the side wall, slide it out to the right. The point is that the driving arms should come with the wall. Since the position sensor is fastened to the right wall that cord has to be unplugged from the sensor PCB in order to completely remove the right wall.



10.
The driving arms with their shafts should slide out as easily out of the right wall as it did out of the left wall. Remove the arms so that the bearings will not be exposed to wrong type of stress.

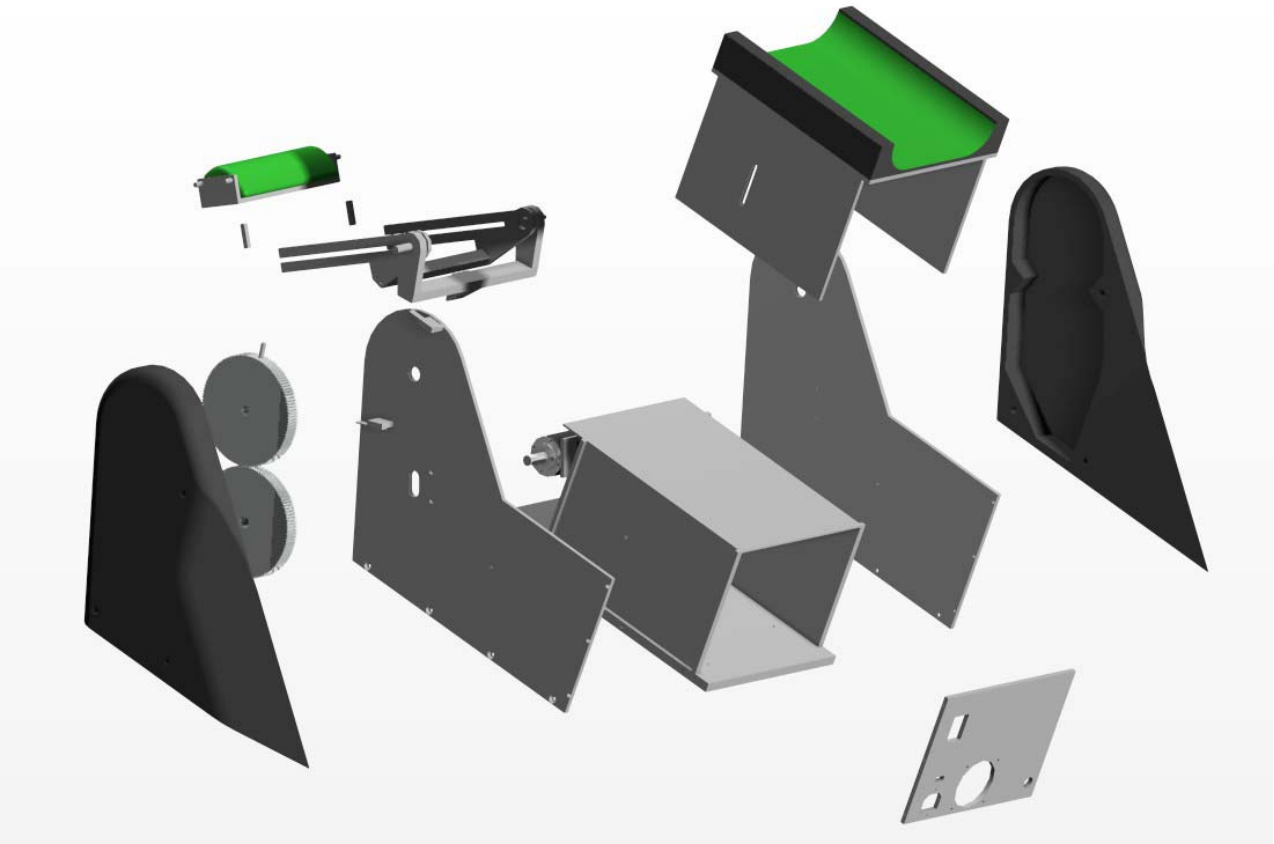


11.
When this is done the left side should easily be removed by removing the four screws that hold it to the bottom plate. To remove the side completely, the cables running from the emergency stops to the relay has to be removed at the relay.



12.
Now it should look like the picture on the left with all the electronics exposed. If any parts such as the power supply or any of the PCB's needs to be removed they are simply fastened using screws.

2.3. Exploded view

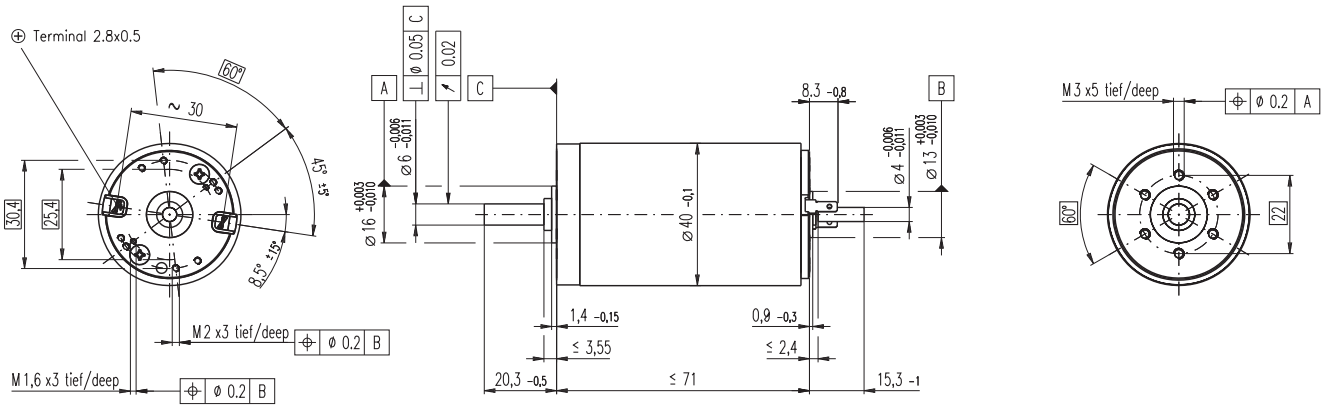


APPENDIX K

DC MOTOR, ENCODER & SERVOAMPLIFIER

MedTech – MF2003
2008-05-13

RE 40 ∅40 mm, Graphite Brushes, 150 Watt



M 1:2

Stock program
Standard program
Special program (on request)

Order Number	148866	148867	148877	218008	218009	218010	218011	218012	218013	218014	218015
Motor Data											
Values at nominal voltage											
1 Nominal voltage V	12.0	24.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0
2 No load speed rpm	6920	7580	7580	6420	5560	3330	2690	2130	1710	1420	987
3 No load current mA	241	137	68.6	53.7	43.7	21.9	16.7	12.5	9.67	7.77	5.16
4 Nominal speed rpm	6370	6930	7000	5810	4920	2700	2050	1500	1080	774	339
5 Nominal torque (max. continuous torque) mNm	94.9	170	184	183	177	187	187	189	189	188	188
6 Nominal current (max. continuous current) A	6.00	5.77	3.12	2.62	2.20	1.38	1.12	0.898	0.721	0.593	0.413
7 Stall torque mNm	1680	2280	2500	1990	1580	995	796	641	512	415	289
8 Starting current A	102	75.7	41.4	28.0	19.2	7.26	4.68	3.00	1.92	1.29	0.627
9 Max. efficiency %	88	91	92	91	91	89	88	87	86	85	83
Characteristics											
10 Terminal resistance Ω	0.117	0.317	1.16	1.72	2.50	6.61	10.2	16.0	24.9	37.1	76.6
11 Terminal inductance mH	0.0245	0.0823	0.329	0.460	0.612	1.70	2.62	4.14	6.40	9.31	19.2
12 Torque constant mNm / A	16.4	30.2	60.3	71.3	82.2	137	170	214	266	321	461
13 Speed constant rpm / V	581	317	158	134	116	69.7	56.2	44.7	35.9	29.8	20.7
14 Speed / torque gradient rpm / mNm	4.15	3.33	3.04	3.23	3.53	3.36	3.39	3.35	3.37	3.44	3.45
15 Mechanical time constant ms	6.03	4.81	4.39	4.36	4.35	4.31	4.31	4.31	4.31	4.32	4.33
16 Rotor inertia gcm²	139	138	138	129	118	123	121	123	122	120	120

Specifications

Thermal data

17	Thermal resistance housing-ambient	4.65 K / W
18	Thermal resistance winding-housing	1.93 K / W
19	Thermal time constant winding	41.6 s
20	Thermal time constant motor	1120 s
21	Ambient temperature	-30 ... +100°C
22	Max. permissible winding temperature	+155°C

Mechanical data (ball bearings)

23	Max. permissible speed	12000 rpm
24	Axial play	0.05 - 0.15 mm
25	Radial play	0.025 mm
26	Max. axial load (dynamic)	5.6 N
27	Max. force for press fits (static)	110 N
	(static, shaft supported)	1200 N
28	Max. radial loading, 5 mm from flange	28 N

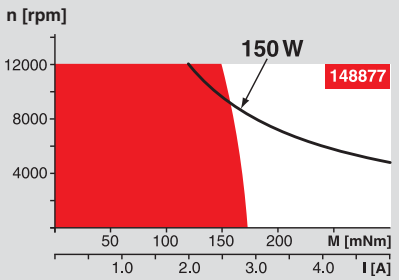
Other specifications

29	Number of pole pairs	1
30	Number of commutator segments	13
31	Weight of motor	480 g

Values listed in the table are nominal.
Explanation of the figures on page 49.

Option
Preloaded ball bearings

Operating Range



Comments

Continuous operation
In observation of above listed thermal resistance (lines 17 and 18) the maximum permissible winding temperature will be reached during continuous operation at 25°C ambient.
= Thermal limit.

Short term operation
The motor may be briefly overloaded (recurring).

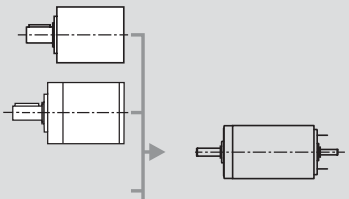
Assigned power rating

maxon Modular System

Overview on page 16 - 21

Planetary Gearhead
∅42 mm
3 - 15 Nm
Page 244

Planetary Gearhead
∅52 mm
4 - 30 Nm
Page 247



Recommended Electronics:

ADS 50/5	Page 276
ADS 50/10	277
ADS_E 50/5	277
ADS_E 50/10	277
EPOS 24/5	294
EPOS2 50/5	295
EPOS 70/10	295
EPOS P 24/5	297
Notes	**18**

Encoder MR
256 - 1024 CPT,
3 channels
Page 259

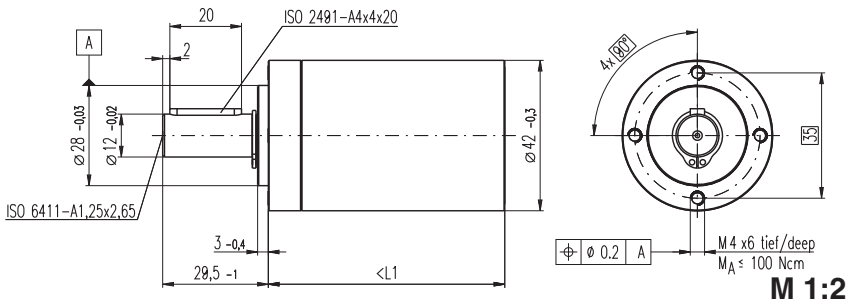
Encoder HED_ 5540
500 CPT,
3 channels
Page 262 / 264

Brake AB 28
∅45 mm
24 VDC, 0.4 Nm
Page 308

Industrial Version
Encoder HEDL 9140
Page 267
Brake AB 28
Page 309

Planetary Gearhead GP 42 C ∅42 mm, 3 - 15 Nm

Ceramic Version



M 1:2

Technical Data

Planetary Gearhead				straight teeth
Output shaft				stainless steel
Bearing at output				preloaded ball bearings
Radial play, 12 mm from flange				max. 0.06 mm
Axial play at axial load	< 5 N			0 mm
	> 5 N			max. 0.3 mm
Max. permissible axial load				150 N
Max. permissible force for press fits				300 N
Sense of rotation, drive to output				=
Recommended input speed				< 8000 rpm
Recommended temperature range				-20 ... +100°C
Extended area as option				-35 ... +100°C
Number of stages	1	2	3	4
Max. radial load, 12 mm from flange	120 N	150 N	150 N	150 N

Stock program
Standard program
Special program (on request)

Gearhead Data			Order Number									
			203113	203115	203119	203120	203124	203129	203128	203133	203137	203141
1	Reduction		3.5 : 1	12 : 1	26 : 1	43 : 1	81 : 1	156 : 1	150 : 1	285 : 1	441 : 1	756 : 1
2	Reduction absolute		7/2	49/4	26	343/8	2197/27	156	2401/16	15379/54	441	756
3	Mass inertia	gcm²	14	15	9.1	15	9.4	9.1	15	15	14	14
4	Max. motor shaft diameter	mm	10	10	8	10	8	8	10	10	10	10
	Order Number		**203114**	**203116**		203121	203125		203130	**203134**	203138	**203142**
1	Reduction		4.3 : 1	15 : 1		53 : 1	91 : 1		186 : 1	319 : 1	488 : 1	936 : 1
2	Reduction absolute		13/3	91/6		637/12	91		4459/24	637/2	4394/9	936
3	Mass inertia	gcm²	9.1	15		15	15		15	15	9.4	9.1
4	Max. motor shaft diameter	mm	8	10		10	10		10	10	8	8
	Order Number			203117		203122	**203126**		**203131**	203135	**203139**	
1	Reduction			19 : 1		66 : 1	113 : 1		230 : 1	353 :1	546 : 1	
2	Reduction absolute			169/9		1183/18	338/3		8281/36	28561/81	546	
3	Mass inertia	gcm²		9.4		15	9.4		15	9.4	14	
4	Max. motor shaft diameter	mm		8		10	8		10	8	10	
	Order Number			203118		**203123**	203127		203132	203136	203140	
1	Reduction			21 : 1		74 : 1	126 : 1		257 : 1	394 : 1	676 : 1	
2	Reduction absolute			21		147/2	126		1029/4	1183/3	676	
3	Mass inertia	gcm²		14		15	14		15	15	9.1	
4	Max. motor shaft diameter	mm		10		10	10		10	10	8	
5	Number of stages		1	2	2	3	3	3	4	4	4	4
6	Max. continuous torque	Nm	3.0	7.5	7.5	15.0	15.0	15.0	15.0	15.0	15.0	15.0
7	Intermittently permissible torque at gear output	Nm	4.5	11.3	11.3	22.5	22.5	22.5	22.5	22.5	22.5	22.5
8	Max. efficiency	%	90	81	81	72	72	72	64	64	64	64
9	Weight	g	260	360	360	460	460	460	560	560	560	560
10	Average backlash no load	°	0.3	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5
11	Gearhead length L1*	mm	40.9	55.4	55.4	69.9	69.9	69.9	84.4	84.4	84.4	84.4

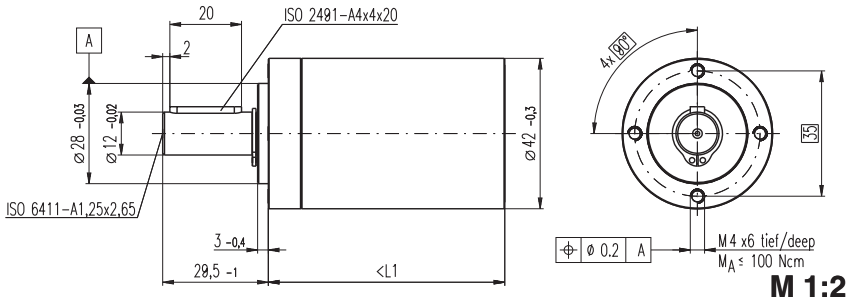
*for EC 45 flat is L1 - 3.5 mm

Combination

+ Motor	Page	+ Tacho	Page	+ Brake	Page	Overall length [mm] = Motor length + gearhead length + (tacho / brake) + assembly parts									
RE 35, 90 W	82					111.9	126.4	126.4	140.9	140.9	140.9	155.4	155.4	155.4	155.4
RE 35, 90 W	82	MR	259			123.3	137.8	137.8	152.3	152.3	152.3	166.8	166.8	166.8	166.8
RE 35, 90 W	82	HED_ 5540	262/264			132.9	147.4	147.4	161.9	161.9	161.9	176.4	176.4	176.4	176.4
RE 35, 90 W	82	DCT 22	271			130.0	144.5	144.5	159.0	159.0	159.0	173.5	173.5	173.5	173.5
RE 35, 90 W	82			AB 28	308	148.0	162.5	162.5	177.0	177.0	177.0	191.5	191.5	191.5	191.5
RE 36, 70 W	83					112.2	126.7	126.7	141.2	141.2	141.2	155.7	155.7	155.7	155.7
RE 36, 70 W	83	MR	259			123.6	138.1	138.1	152.6	152.6	152.6	167.1	167.1	167.1	167.1
RE 36, 70 W	83	HED_ 5540	262/264			133.2	147.7	147.7	162.2	162.2	162.2	176.7	176.7	176.7	176.7
RE 36, 70 W	83	DCT 22	271			130.3	144.8	144.8	159.3	159.3	159.3	173.8	173.8	173.8	173.8
RE 40, 150 W	84					112.0	126.5	126.5	141.0	141.0	141.0	155.5	155.5	155.5	155.5
RE 40, 150 W	84	MR	259			123.4	137.9	137.9	152.4	152.4	152.4	166.9	166.9	166.9	166.9
RE 40, 150 W	84	HED_ 5540	262/264			132.7	147.2	147.2	161.7	161.7	161.7	176.2	176.2	176.2	176.2
RE 40, 150 W	84	HEDL 9140	267			166.1	180.6	180.6	195.1	195.1	195.1	209.6	209.6	209.6	209.6
RE 40, 150 W	84			AB 28	308	148.1	162.6	162.6	177.1	177.1	177.1	191.6	191.6	191.6	191.6
RE 40, 150 W	84			AB 28	309	156.1	170.6	170.6	185.1	185.1	185.1	199.6	199.6	199.6	199.6
RE 40, 150 W	84	HED_ 5540	262/264	AB 28	308	165.2	179.7	179.7	194.2	194.2	194.2	208.7	208.7	208.7	208.7
RE 40, 150 W	84	HEDL 9140	267	AB 28	309	176.6	191.1	191.1	205.6	205.6	205.6	220.1	220.1	220.1	220.1
EC 40, 120 W	165					111.0	125.5	125.5	140.0	140.0	140.0	154.5	154.5	154.5	154.5
EC 40, 120 W	165	HED_ 5540	263/265			129.4	143.9	143.9	158.4	158.4	158.4	172.9	172.9	172.9	172.9
EC 40, 120 W	165	Res 26	272			137.6	152.1	152.1	166.6	166.6	166.6	181.1	181.1	181.1	181.1
EC 40, 120 W	165			AB 28	308	141.8	156.3	156.3	170.8	170.8	170.8	185.3	185.3	185.3	185.3
EC 45, 150 W	166					152.2	166.7	166.7	181.2	181.2	181.2	195.7	195.7	195.7	195.7
EC 45, 150 W	166	HEDL 9140	267			167.8	182.3	182.3	196.8	196.8	196.8	211.3	211.3	211.3	211.3
EC 45, 150 W	166	Res 26	272			152.2	166.7	166.7	181.2	181.2	181.2	195.7	195.7	195.7	195.7
EC 45, 150 W	166			AB 28	309	159.6	174.1	174.1	188.6	188.6	188.6	203.1	203.1	203.1	203.1
EC 45, 150 W	166	HEDL 9140	267	AB 28	309	176.6	191.1	191.1	205.6	205.6	205.6	220.1	220.1	220.1	220.1
EC 45 flat, 30 W	202					53.9	68.4	68.4	82.9	82.9	82.9	97.4	97.4	97.4	97.4
EC 45 flat, 50 W	203					58.8	73.3	73.3	87.8	87.8	87.8	102.3	102.3	102.3	102.3
EC 45 fl, IE, IP 00	204					72.8	87.3	87.3	101.8	101.8	101.8	116.3	116.3	116.3	116.3
EC 45 fl, IE, IP 40	204					75.0	89.5	89.5	104.0	104.0	104.0	118.5	118.5	118.5	118.5
EC 45 fl, IE, IP 00	205					77.8	92.3	92.3	106.8	106.8	106.8	121.3	121.3	121.3	121.3
EC 45 fl, IE, IP 40	205					80.0	94.5	94.5	109.0	109.0	109.0	123.5	123.5	123.5	123.5

Planetary Gearhead GP 42 C ∅42 mm, 3 - 15 Nm

Ceramic Version



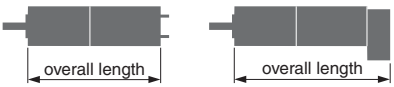
M 1:2

Technical Data

Planetary Gearhead				straight teeth
Output shaft				stainless steel
Bearing at output				preloaded ball bearings
Radial play, 12 mm from flange				max. 0.06 mm
Axial play at axial load	< 5 N			0 mm
	> 5 N			max. 0.3 mm
Max. permissible axial load				150 N
Max. permissible force for press fits				300 N
Sense of rotation, drive to output				=
Recommended input speed				< 8000 rpm
Recommended temperature range				-20 ... +100°C
Extended area as option				-35 ... +100°C
Number of stages	1	2	3	4
Max. radial load, 12 mm from flange	120 N	150 N	150 N	150 N

Stock program
Standard program
Special program (on request)

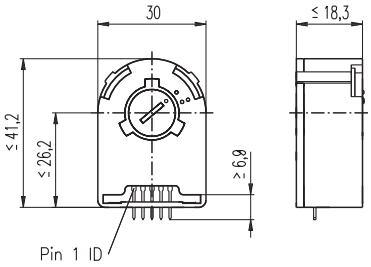
			Order Number									
			203113	203115	203119	203120	203124	203129	203128	203133	203137	203141
Gearhead Data												
1	Reduction		3.5 : 1	12 : 1	26 : 1	43 : 1	81 : 1	156 : 1	150 : 1	285 : 1	441 : 1	756 : 1
2	Reduction absolute		$^{7}/_{2}$	$^{49}/_{4}$	26	$^{343}/_{8}$	$^{2197}/_{27}$	156	$^{2401}/_{16}$	$^{15379}/_{54}$	441	756
3	Mass inertia	gcm²	14	15	9.1	15	9.4	9.1	15	15	14	14
4	Max. motor shaft diameter	mm	10	10	8	10	8	8	10	10	10	10
	Order Number		**203114**	**203116**		203121	203125		203130	**203134**	203138	**203142**
1	Reduction		4.3 : 1	15 : 1		53 : 1	91 : 1		186 : 1	319 : 1	488 : 1	936 : 1
2	Reduction absolute		$^{13}/_{3}$	$^{91}/_{6}$		$^{637}/_{12}$	91		$^{4459}/_{24}$	$^{637}/_{2}$	$^{4394}/_{9}$	936
3	Mass inertia	gcm²	9.1	15		15	15		15	15	9.4	9.1
4	Max. motor shaft diameter	mm	8	10		10	10		10	10	8	8
	Order Number			203117		203122	**203126**		**203131**	203135	**203139**	
1	Reduction			19 : 1		66 : 1	113 : 1		230 : 1	353 :1	546 : 1	
2	Reduction absolute			$^{169}/_{9}$		$^{1183}/_{18}$	$^{338}/_{3}$		$^{8281}/_{36}$	$^{28561}/_{81}$	546	
3	Mass inertia	gcm²		9.4		15	9.4		15	9.4	14	
4	Max. motor shaft diameter	mm		8		10	8		10	8	10	
	Order Number			203118		**203123**	203127		203132	203136	203140	
1	Reduction			21 : 1		74 : 1	126 : 1		257 : 1	394 : 1	676 : 1	
2	Reduction absolute			21		$^{147}/_{2}$	126		$^{1029}/_{4}$	$^{1183}/_{3}$	676	
3	Mass inertia	gcm²		14		15	14		15	15	9.1	
4	Max. motor shaft diameter	mm		10		10	10		10	10	8	
5	Number of stages		1	2	2	3	3	3	4	4	4	4
6	Max. continuous torque	Nm	3.0	7.5	7.5	15.0	15.0	15.0	15.0	15.0	15.0	15.0
7	Intermittently permissible torque at gear output	Nm	4.5	11.3	11.3	22.5	22.5	22.5	22.5	22.5	22.5	22.5
8	Max. efficiency	%	90	81	81	72	72	72	64	64	64	64
9	Weight	g	260	360	360	460	460	460	560	560	560	560
10	Average backlash no load	°	0.3	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5
11	Gearhead length L1	mm	40.9	55.4	55.4	69.9	69.9	69.9	84.4	84.4	84.4	84.4

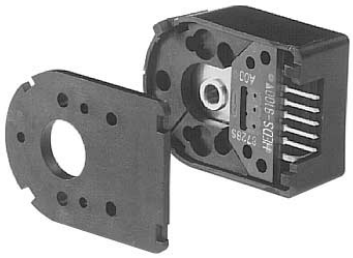


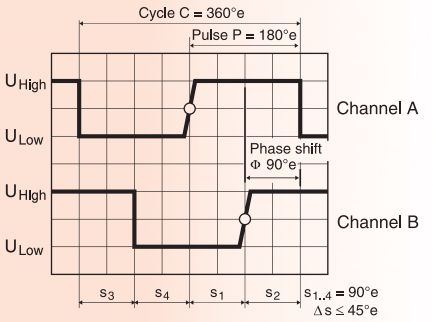
Combination

+ Motor	Page	+ Tacho	Page	+ Brake	Page	**Overall length [mm]** = Motor length + gearhead length + (tacho / brake) + assembly parts									
EC 45, 250 W	167					185.0	199.5	199.5	214.0	214.0	214.0	228.5	228.5	228.5	228.5
EC 45, 250 W	167	HEDL 9140	267			200.6	215.1	215.1	229.6	229.6	229.6	244.1	244.1	244.1	244.1
EC 45, 250 W	167	Res 26	272			185.0	199.5	199.5	214.0	214.0	214.0	228.5	228.5	228.5	228.5
EC 45, 250 W	167			AB 28	309	192.4	206.9	206.9	221.4	221.4	221.4	235.9	235.9	235.9	235.9
EC 45, 250 W	167	HEDL 9140	267	AB 28	309	209.4	223.9	223.9	238.4	238.4	238.4	252.9	252.9	252.9	252.9
EC-max 30, 60 W	179					105.0	119.5	119.5	134.0	134.0	134.0	148.5	148.5	148.5	148.5
EC-max 30, 60 W	179	MR	258			117.2	131.7	131.7	146.2	146.2	146.2	160.7	160.7	160.7	160.7
EC-max 30, 60 W	179	HEDL 5540	266			125.6	140.1	140.1	154.6	154.6	154.6	169.1	169.1	169.1	169.1
EC-max 30, 60 W	179			AB 20	306	140.6	155.1	155.1	169.6	169.6	169.6	184.1	184.1	184.1	184.1
EC-max 30, 60 W	179	HEDL 5540	266	AB 20	306	164.6	179.1	179.1	193.6	193.6	193.6	208.1	208.1	208.1	208.1
EC-max 40, 70 W	180					99.0	113.5	113.5	128.0	128.0	128.0	142.5	142.5	142.5	142.5
EC-max 40, 70 W	180	MR	259			114.9	129.4	129.4	143.9	143.9	143.9	158.4	158.4	158.4	158.4
EC-max 40, 70 W	180	HEDL 5540	266			122.4	136.9	136.9	151.4	151.4	151.4	165.9	165.9	165.9	165.9
EC-max 40, 70 W	180			AB 28	307	139.0	153.5	153.5	168.0	168.0	168.0	182.5	182.5	182.5	182.5
EC-max 40, 70 W	180	HEDL 5540	266	AB 28	307	162.4	176.9	176.9	191.4	191.4	191.4	205.9	205.9	205.9	205.9
EC-power 30, 100 W	187					88.0	102.5	102.5	117.0	117.0	117.0	131.5	131.5	131.5	131.5
EC-power 30, 100 W	187	MR	259			100.2	114.7	114.7	129.2	129.2	129.2	143.7	143.7	143.7	143.7
EC-power 30, 100 W	187	HEDL 5540	266			108.6	123.1	123.1	137.6	137.6	137.6	152.1	152.1	152.1	152.1
EC-power 30, 100 W	187			AB 20	306	124.2	138.7	138.7	153.2	153.2	153.2	167.7	167.7	167.7	167.7
EC-power 30, 100 W	187	HEDL 5540	266	AB 20	306	145.0	159.5	159.5	174.0	174.0	174.0	188.5	188.5	188.5	188.5
EC-power 30, 200 W	188					105.0	119.5	119.5	134.0	134.0	134.0	148.5	148.5	148.5	148.5
EC-power 30, 200 W	188	MR	259			117.2	131.7	131.7	146.2	146.2	146.2	160.7	160.7	160.7	160.7
EC-power 30, 200 W	188	HEDL 5540	266			125.6	140.1	140.1	154.6	154.6	154.6	169.1	169.1	169.1	169.1
EC-power 30, 200 W	188			AB 20	306	141.2	155.7	155.7	170.2	170.2	170.2	184.7	184.7	184.7	184.7
EC-power 30, 200 W	188	HEDL 5540	266	AB 20	306	162.0	176.5	176.5	191.0	191.0	191.0	205.5	205.5	205.5	205.5
MCD EPOS, 60 W	303					161.0	175.5	175.5	190.0	190.0	190.0	204.5	204.5	204.5	204.5
MCD EPOS P, 60 W	303					161.0	175.5	175.5	190.0	190.0	190.0	204.5	204.5	204.5	204.5

Encoder HEDS 5540, 500 Counts per turn, 3 Channels

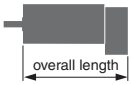


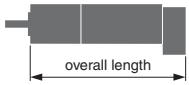




Stock program
Standard program
Special program (on request)

Order Number	110511	110513	110515
Type			
Counts per turn	500	500	500
Number of channels	3	3	3
Max. operating frequency (kHz)	100	100	100
Shaft diameter (mm)	3	4	6





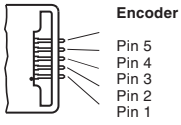
Combination

+ Motor	Page	+ Gearhead	Page	+ Brake	Page	Overall length [mm] / ● see: + Gearhead					
RE 25, 10 W	77					75.3					
RE 25, 10 W	77	GP 26, 0.5 - 2.0 Nm	235			●					
RE 25, 10 W	77	GP 32, 0.4 - 2.0 Nm	237			●					
RE 25, 10 W	77	GP 32, 0.75 - 6.0 Nm	238/240			●					
RE 25, 20 W	79					75.3					
RE 25, 20 W	79	GP 26, 0.5 - 2.0 Nm	235			●					
RE 25, 20 W	79	GP 32, 0.4 - 2.0 Nm	237			●					
RE 25, 20 W	79	GP 32, 0.75 - 6.0 Nm	238/240			●					
RE 25, 20 W	79			AB 28	308	105.7					
RE 25, 20 W	79	GP 26, 0.5 - 2.0 Nm	235	AB 28	308	●					
RE 25, 20 W	79	GP 32, 0.4 - 2.0 Nm	237	AB 28	308	●					
RE 25, 20 W	79	GP 32, 0.75 - 6.0 Nm	238/240	AB 28	308	●					
RE 26, 18 W	80					77.2					
RE 26, 18 W	80	GP 26, 0.5 - 2.0 Nm	235			●					
RE 26, 18 W	80	GP 32, 0.4 - 2.0 Nm	237			●					
RE 26, 18 W	80	GP 32, 0.75 - 6.0 Nm	238/240			●					
RE 35, 90 W	82						91.9				
RE 35, 90 W	82	GP 32, 0.75 - 6.0 Nm	239/240				●				
RE 35, 90 W	82	GP 32, 8 Nm	242				●				
RE 35, 90 W	82	GP 42, 3.0 - 15 Nm	244				●				
RE 35, 90 W	82			AB 28	308	124.1					
RE 35, 90 W	82	GP 32, 0.75 - 6.0 Nm	239/240	AB 28	308	●					
RE 35, 90 W	82	GP 42, 3.0 - 15 Nm	244	AB 28	308	●					
RE 36, 70 W	83						92.2				
RE 36, 70 W	83	GP 32, 0.4 - 2.0 Nm	237				●				
RE 36, 70 W	83	GP 32, 0.75 - 6.0 Nm	239/240				●				
RE 36, 70 W	83	GP 42, 3.0 - 15 Nm	244				●				
RE 40, 150 W	84						91.7				
RE 40, 150 W	84	GP 42, 3.0 - 15 Nm	244				●				
RE 40, 150 W	84	GP 52, 4.0 - 30 Nm	247				●				
RE 40, 150 W	84			AB 28	308	124.2					
RE 40, 150 W	84	GP 42, 3.0 - 15 Nm	244	AB 28	308	●					
RE 40, 150 W	84	GP 52, 4.0 - 30 Nm	247	AB 28	308	●					

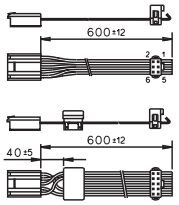
Technical Data

Supply voltage	5 V ± 10 %
Output signal	TTL compatible
Phase shift F (nominal)	90°e ± 45°e
Signal rise time (typical at C_L = 25 pF, R_L = 2.7 kΩ, 25°C)	180 ns
Signal fall time (typical at C_L = 25 pF, R_L = 2.7 kΩ, 25°C)	40 ns
Index pulse width (nominal)	90°e
Operating temperature range	-40 ... +100°C
Moment of inertia of code wheel	≤ 0.6 gcm²
Max. angular acceleration	250 000 rad s^{-2}
Output current per channel	min. -1 mA, max. 5 mA

Pin Allocation



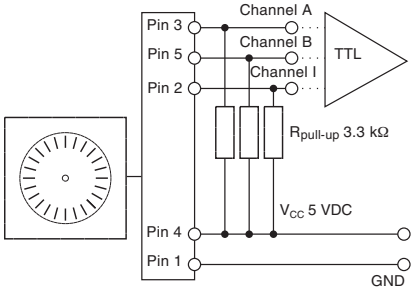
Encoder	Description	Pin no. from 3409.506
Pin 5	Channel B	1
Pin 4	V_{CC}	2
Pin 3	Channel A	3
Pin 2	Channel I	4
Pin 1	GND	5



Cable with plug:
maxon Art. No. 3409.506
The plug (Harting 09185066803) can be fixed in the required position.

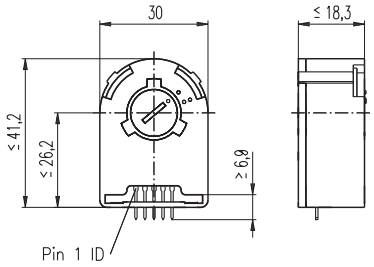
Cable with plug: (compatible with Encoder HEDS5010)
maxon Art. No. 3409.504
The plug (3M 89110-0101) can be fixed in the required position.

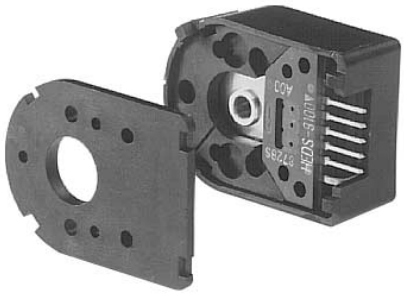
Connection example

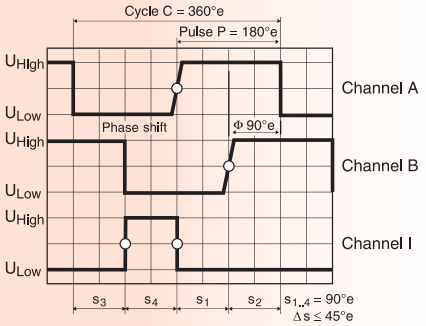


Ambient temperature range δ_U = 25°C

Encoder HEDS 5540, 500 Counts per turn, 3 Channels

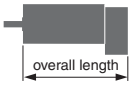


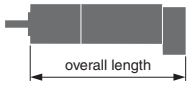




Stock program
Standard program
Special program (on request)

Order Number	110511	110513	110515	110517
Type				
Counts per turn	500	500	500	500
Number of channels	3	3	3	3
Max. operating frequency (kHz)	100	100	100	100
Shaft diameter (mm)	3	4	6	8





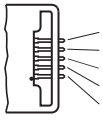
Combination

+ Motor	Page	+ Gearhead	Page	+ Brake	Page	Overall length [mm] / ● see: + Gearhead			
RE 65, 250 W	85								157.3
RE 65, 250 W	85	GP 81, 20 - 120 Nm	250						●
RE 75, 250 W	86								241.5
RE 75, 250 W	86	GP 81, 20 - 120 Nm	250						●
RE 75, 250 W	86			AB 75	311				281.4
RE 75, 250 W	86	GP 81, 20 - 120 Nm	250	AB 75	311				●
F 2260, 40 W	97						111.9		
F 2260, 40 W	97	GP 62, 8.0 - 50 Nm	249				●		
F 2260, 80 W	98						147.4		
F 2260, 80 W	98	GP 62, 8.0 - 50 Nm	249				●		
A-max 26	116-122					63.5			
A-max 26	116-122	GP 26, 0.5 - 2.0 Nm	235			●			
A-max 26	116-122	GS 30, 0.07 - 0.2 Nm	236			●			
A-max 26	116-122	GP 32, 0.4 - 2.0 Nm	237			●			
A-max 26	116-122	GP 32, 0.75 - 6.0 Nm	238/241			●			
A-max 26	116-122	GS 38, 0.1 - 0.6 Nm	243			●			
A-max 32	124/126						82.3		
A-max 32	124/126	GP 32, 0.75 - 6.0 Nm	239/241				●		
A-max 32	124/126	GS 38, 0.1 - 0.6 Nm	243				●		
EC 32, 80 W	164						78.4		
EC 32, 80 W	164	GP 32, 0.75 - 6.0 Nm	239/241				●		
EC 40, 120 W	165							88.4	
EC 40, 120 W	165	GP 42, 3.0 - 15 Nm	244					●	
EC 40, 120 W	165	GP 52, 4.0 - 30 Nm	247					●	

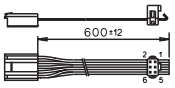
Technical Data

Supply voltage	5 V ± 10 %
Output signal	TTL compatible
Phase shift F (nominal)	90°e ± 45°e
Signal rise time (typical at C_L = 25 pF, R_L = 2.7 kΩ, 25°C)	180 ns
Signal fall time (typical at C_L = 25 pF, R_L = 2.7 kΩ, 25°C)	40 ns
Index pulse width (nominal)	90°e
Operating temperature range	-40 ... +100°C
Moment of inertia of code wheel	≤ 0.6 gcm²
Max. angular acceleration	250 000 rad s⁻²
Output current per channel	min. -1 mA, max. 5 mA

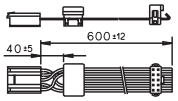
Pin Allocation



Encoder	Description	Pin no. from 3409.506
Pin 5	Channel B	1
Pin 4	V_{CC}	2
Pin 3	Channel A	3
Pin 2	Channel I	4
Pin 1	GND	5

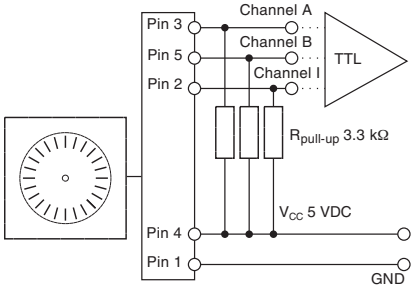


Cable with plug:
maxon Art. Nr. 3409.506
The plug (Harting 918.906.6803) can be fixed in the required position.



Cable with plug: (compatible with Encoder HEDS5010)
maxon Art. No. 3409.504
The plug (3M 891100101) can be fixed in the required position.

Connection example



Ambient temperature range δ_U = 25°C

ADS 50/10 4-Q-DC Servoamplifier
Powerful PWM servoamplifier for permanent magnet activated DC motors from 80 to approx. 500 watts output power.
Available as Power Version in module housing.

ADS_E 50/5 4-Q-DC Servoamplifier
Powerful PWM servoamplifier for permanent magnet activated DC motors from 10 to approx. 250 watts output power.
Available as Standard Version in Eurocard format.

ADS_E 50/10 4-Q-DC Servoamplifier
Powerful PWM servoamplifier for permanent magnet activated DC motors from 80 to approx. 500 watts output power.
Available as Power Version in Eurocard format.

Operating modes		
IxR compensation, encoder speed control, DC tacho speed control, current control	**IxR compensation, encoder speed control, DC tacho speed control, current control**	**IxR compensation, encoder speed control, DC tacho speed control, current control**
Electrical Data		
12 - 50 VDC	12 - 50 VDC	12 - 50 VDC
0.9 x V_{CC}	0.9 x V_{CC}	0.9 x V_{CC}
20 A	10 A	20 A
10 A	5 A	10 A
50 kHz	50 kHz	50 kHz
95 %	95 %	95 %
75 µH / 10 A	150 µH / 5 A	75 µH / 10 A
Input		
-10 … +10 V	-10 … +10 V	-10 … +10 V
«Enable» +4 … +50 V	«Enable» +4 … +50 V	«Enable» +4 … +50 V
Min. 2 VDC, max. 50 VDC	Min. 2 VDC, max. 50 VDC	Min. 2 VDC, max. 50 VDC
Channel A, A\, B, B\, max. 100 kHz, TTL	Channel A, A\, B, B\, max. 100 kHz, TTL	Channel A, A\, B, B\, max. 100 kHz, TTL
Output		
Open collector, max. 30 VDC (I_L < 20 mA)	Open collector max. 30 VDC (I_L < 20 mA)	Open collector max. 30 VDC (I_L < 20 mA)
-10 … +10 VDC (short circuit protected)	-10 … +10 VDC (short circuit protected)	-10 … +10 VDC (short circuit protected)
-10 … +10 VDC (short circuit protected)	-10 … +10 VDC (short circuit protected)	-10 … +10 VDC (short circuit protected)
Voltage outputs		
+12 VDC, -12 VDC, max. 12 mA (short circuit prot.)	+12 VDC, -12 VDC, max. 12 mA (short circuit prot.)	+12 VDC, -12 VDC, max. 12 mA (short circuit prot.)
+5 VDC, max. 80 mA	+5 VDC, max. 80 mA	+5 VDC, max. 80 mA
I x R compensation, Offset, n_{max}, I_{max}, gain	I x R compensation, Offset, n_{max}, I_{max}, gain	I x R compensation, Offset, n_{max}, I_{max}, gain
Protected against over temperature, overcurrent and short-circuit of motor	Protected against over temperature, overcurrent and short-circuit of motor	Protected against over temperature, overcurrent and short-circuit of motor
Bi-colour LED, green = READY, red = ERROR	Bi-colour LED, green = READY, red = ERROR	Bi-colour LED, green = READY, red = ERROR
Ambient temperature / Humidity range		
-10 … +45°C	-10 … +45°C	-10 … +45°C
-40 … +85°C	-40 … +85°C	-40 … +85°C
20 … 80 %	20 … 80 %	20 … 80 %
Mechanical data		
Approx. 400 g	Approx. 175 g	Approx. 410 g
180 x 103 x 26 mm (see page 278)	160 x 100 x 16 mm (see page 278)	160 x 100 x 30.5 mm (see page 278)
Flange for M4-screws	Rack-Installation	Rack-Installation
See page 278	See page 278	See page 278
Order Number		
201583 ADS 50/10 4-Q-DC Servoamplifier Power Version in module housing	**166143** ADS_E 50/5 4-Q-DC Servoamplifier Standard Version in Eurocard format	**168049** ADS_E 50/10 4-Q-DC Servoamplifier Power Version in Eurocard format
Accessories		
235811 DSR 70/30 Shunt regulator	**167850** Front panel 3HE, 5TE **166873** Backplane with screw type terminal block	**168910** Front panel 3HE, 7TE **166873** Backplane with screw type terminal block

maxon motor

maxon motor control 4-Q-DC Servoamplifier ADS 50/10

Order number 201583

Operating Instructions April 2006 Edition

The ADS 50/10 is a powerful servoamplifier for driving permanent magnet DC motors from 80 Watts up to 500 Watts.
Four modes can be selected by DIP switches on the board:

- Speed control using tacho signals
- Speed control using encoder signals
- IxR compensated speed control
- Torque or current control

The ADS 50/10 is protected against excess current, excess temperature and short circuit on the motor winding. With the FET power transistors incorporated in the servoamplifier, an efficiency of up to 95 % is achieved. A built in motor choke combined with the high PWM frequency of 50 kHz allows the connection of motors with a very low inductivity. In most cases an external choke can be omitted.
Thanks to the wide input power supply range of 12 - 50 VDC, the ADS 50/10 is very versatile and can be used with various power supplies. The aluminium housing makes installation simple, with terminal markings for easy connection.

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2 Performance Data 3
3 Minimum External Wiring for Different Modes of Operation 4
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5 Functions 7
6 Additional Possible Adjustments 10
7 Operating Status Display 12
8 Error Handling 13
9 EMC-compliant installation 13
10 Block Diagram 14
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The latest edition of these operating instructions may be downloaded from the internet as a PDF-file under www.maxonmotor.com, category “Service & Downloads”, Order number 201583.

1 Safety Instructions

Skilled Personnel
Installation and starting of the equipment shall only be performed by experienced, skilled personnel.

Statutory Regulations
The user must ensure that the servoamplifier and the components belonging to it are assembled and connected according to local statutory regulations.

Load Disconnected
For primary operation the motor should be free running, i.e. with the load disconnected.

Additional Safety Equipment
An electronic apparatus is not fail-safe in principle. Machines and apparatus must therefore be fitted with independent monitoring and safety equipment. If the equipment breaks down, if it is operated incorrectly, if the control unit breaks down or if the cables break, etc., it must be ensured that the drive or the complete apparatus is kept in a safe operating mode.

Repairs
Repairs may be made by authorised personnel only or by the manufacturer. It is dangerous for the user to open the unit or make repairs to it.

Danger
Do ensure that during the installation of the ADS 50/10 no apparatus is connected to the electrical supply. After switching on, do not touch any live parts.

Max. Supply Voltage
Make sure that the supply voltage is between 12 and 50 VDC. Voltages higher than 53 VDC or wrong polarity will destroy the unit.

Short circuit and earth fault
The ADS 50/10 amplifier is not protected against winding short circuits against ground safety earth or Gnd!

Motor choke
The built in motor choke allows operation with almost all maxon DC motors with an output power higher than 80 Watt. If necessary the motor continuous current must be slightly reduced.
Generally the following applies:

$$L_{extern}\left[mH\right] \geq \frac{V_{CC}\left[V\right]}{0.15\left[\frac{1}{s}\right] \cdot I_D\left[mA\right]} - 0.075\left[mH\right] - \frac{L_{Motor}\left[mH\right]}{3}$$

- Supply voltage V_{CC} [V]
- Nominal current (Max. continuous output current) I_D [mA]
- Terminal inductance L_{Motor} [mH]

Sought value:
- Additional required external inductance so that the continuous current only reduces by max. 10% as a result of warming.

Electrostatic Sensitive Device (ESD)

2 Performance Data

2.1 Electrical data

Supply voltage V_{CC} (Ripple < 5%) ..... 12 - 50 VDC
Max. output voltage ..... $0.9 \cdot V_{CC}$
Max. output current I_{max} ..... 20 A
Continuous output current I_{cont} ..... 10 A
Switching frequency ..... 50 kHz
Efficiency ..... 95 %
Band width current controller ..... 2.5 kHz
Built-in motor choke ..... 75 µH / 10 A

2.2 Inputs

Set value ..... -10 ... +10 V (R_i = 20 kΩ)
Enable ..... +4 ... + 50 VDC (R_i = 15 kΩ)
Input voltage DC tacho "Tacho Input" ..... min. 2 VDC, max. 50 VDC (R_i = 14 kΩ)
Encoder signals "Channel A, A\, B, B\" ..... max. 100 kHz, TTL level

2.3 Outputs

Current monitor "Monitor I", short-circuit protected ..... -10 ...+10 VDC (R_O = 100 Ω)
Speed monitor "Monitor n", short-circuit protected ..... -10 ...+10 VDC (R_O = 100 Ω)
Status reading "READY"
Open collector, short-circuit protected ..... max. 30 VDC ($I_L \leq$ 20 mA)

2.4 Voltage outputs

Aux. voltage, short-circuit protected ..... +12 VDC, -12 VDC, max. 12 mA (R_O = 1 kΩ)
Encoder supply voltage ..... +5 VDC, max. 80 mA

2.5 Trim potentiometers

IxR compensation
Offset
n_{max}
I_{max}
gain

2.6 LED indicator

Bi-colour LED ..... READY / ERROR
green = ok, red = error

2.7 Ambient temperature- / Humidity range

Operating ..... -10 ... +45°C
Storage ..... -40 ... +85°C
Non condensating ..... 20 ... 80 %

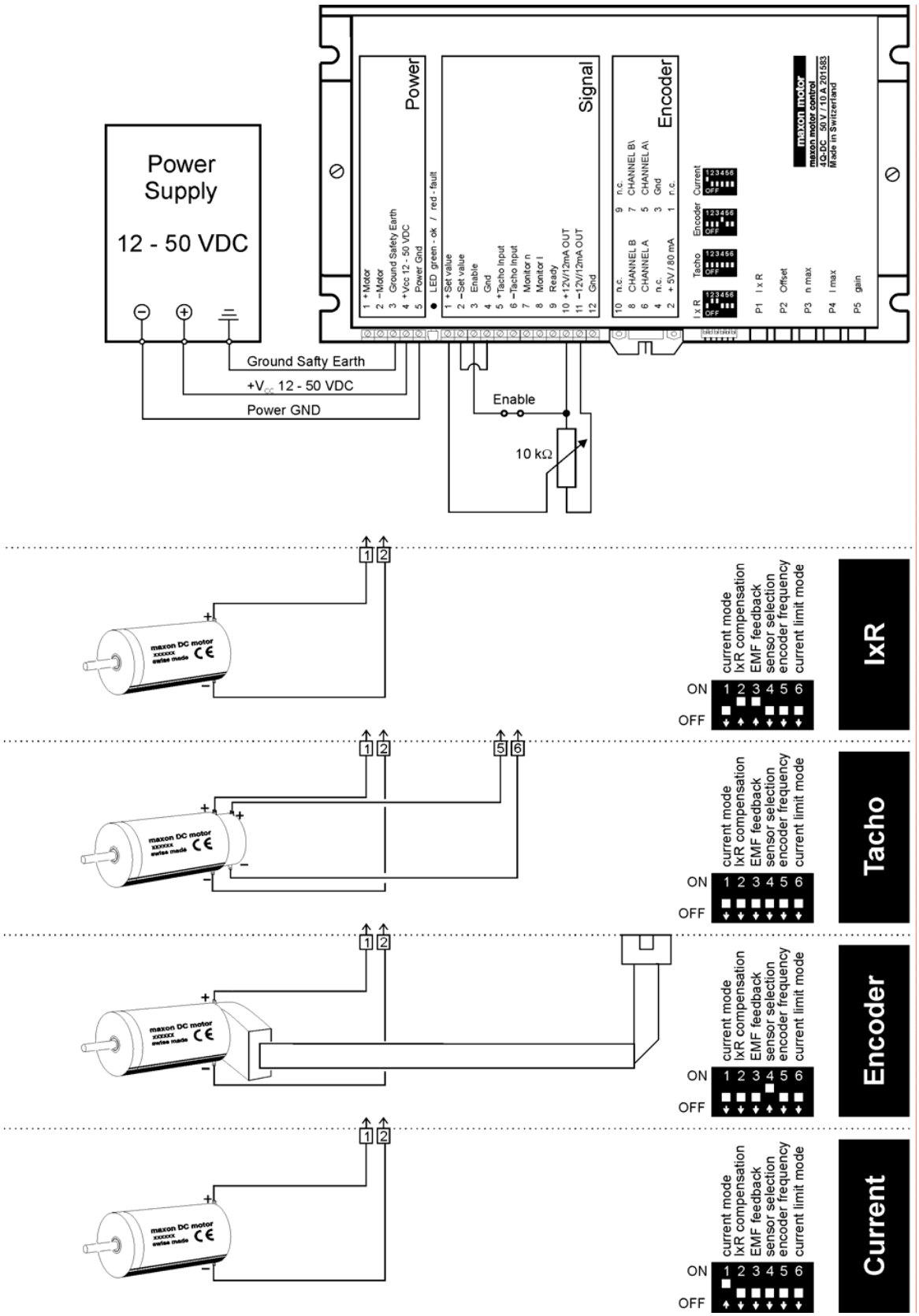
2.8 Mechanical data

Weight ..... ca. 400 g
Dimensions ..... see dimension drawing
Mounting plate ..... for M4 screws

2.9 Terminal

PCB-clamps ..... Power (5 poles), Signal (12 poles)
Pitch ..... 3.81 mm
suitable for wire cross section ..... 0.14 - 1 mm^2 multiple-stranded wire or
..... 0.14 - 1.5 mm^2 single wire
Encoder ..... Plug DIN41651
for flat cable, pitch 1.27 mm, AWG 28

3 Minimum External Wiring for Different Modes of Operation



4 Operating Instructions

4.1 Determine power supply requirements

You may make use of any available power supply, as long as it meets the minimal requirements spelled out below.
During set up and adjustment phases, we recommend separating the motor mechanically from the machine to prevent damage due to uncontrolled motion.

Power supply requirements	
Output voltage	VCC min. 12 VDC; max. 50 VDC
Ripple	< 5 %
Output current	depending on load, continuous 10 A (short-time 20 A)

The required voltage can be calculated as follows:

Known values

- ⇨ Operating torque M_B [mNm]
- ⇨ Operating speed n_B [rpm]
- ⇨ Nominal motor voltage U_N [Volt]
- ⇨ Motor no-load speed at U_N, n_0 [rpm]
- ⇨ Speed/torque gradient of the motor $\Delta n/\Delta M$ [rpm/mNm]

Sought values

- ⇨ Supply voltage V_{CC} [Volt]

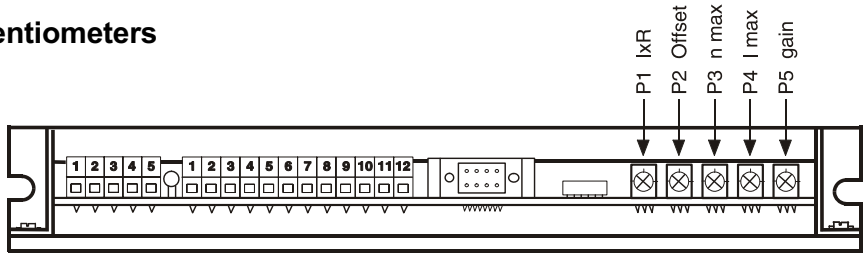
Solution

$$V_{CC} = \frac{U_N}{n_0} \cdot \left(n_B + \frac{\Delta n}{\Delta M} \cdot M_B \right) \cdot \frac{1}{0.9} + 2\,[V]$$

Choose a power supply capable of supplying this calculated voltage under load. The formula takes into account a max. PWM cycle of 90 % and a 2 volt max. voltage drop.

Consider:
The power supply must be able to buffer the back-fed energy from brake operation e.g. in a condenser. With electronically stabilized power supply units it is to ensure, that the over current protection responds in no operating condition.

4.2 Function of the potentiometers

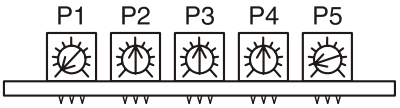


Potentiometer		Function	Turn to the left ↺	Turn to the right ↻
P1	IxR	IxR compensation	weak compensation	strong compensation
P2	Offset	Adjustment n = 0 / I = 0 at set value 0 V	motor turns CCW	motor turns CW
P3	n_{max}	max. speed at 10 V set value	speed slower	speed faster
P4	I_{max}	current limit	lower min. 0.5 A	higher max. 20 A
P5	gain	amplification	lower	higher

4.3 Adjustment of the Potentiometers

4.3.1 Pre-adjustment

With the pre-adjustment, the potentiometers are set in a preferred position. ADS units in original packing are already pre-adjusted.



Pre-adjustment of potentiometers		
P1	IxR	0 %
P2	Offset	50 %
P3	nmax	50 %
P4	Imax	50 %
P5	gain	10 %

4.3.2 Adjustment

Encoder mode
DC-Tacho mode
IxR compensation

1. Adjust set value to maximum (e.g. 10 V) and turn potentiometer **P3 n_{max}** so far that the required speed is achieved.
2. Set potentiometer **P4 I_{max}** at the limiting value desired.
   Maximum current in the 0 ... 20 A range can be adjusted in linear fashion with potentiometer **P4**.
   Important: The limiting value I_{max} should be below the nominal current (max. continuous current) as shown on the motor data sheet and may not exceed 10 A continuously.
3. Increase potentiometer **P5** gain slowly until the amplification is set large enough.
   Caution: If the motor vibrates or becomes loud, the amplification is adjusted too high.
4. Adjust set value to 0 V, e.g. by short circuiting the set value. Then set the motor speed to 0 rpm with the potentiometer **P2 Offset**.

In addition, only in the case of IxR compensation:

5. Slowly increase potentiometer **P1 IxR** until the compensation is set large enough so that in the case of high motor load the motor speed remains the same or decreases only slightly.
   Caution: If the motor vibrates or becomes loud, the amplification is adjusted too high.

Current controller mode

1. Set potentiometer **P4 I_{max}** at the limiting value desired.
   Maximum current in the 0 ... 20 A range can be adjusted in linear fashion with potentiometer **P4**.
   Important: The limiting value I_{max} should be below the nominal current (max. continuous current) as shown in the motor data sheet and may not exceed 10 A
   continuously.
2. Adjust set value to 0 V. Then set the motor current to 0 A with the potentiometer **P2 Offset**.

Note

- A set value in the -10 ... +10 V range is equal to a current range of approx. $+I_{max}$ ... $-I_{max}$
- Configured as a current controller, **P1**, **P3** and **P5** are not activated.

5 Functions

5.1 Inputs

5.1.1 Set value

The set value input is wired as a differential amplifier.

Input voltage range	-10 ... +10 V
Input circuit	differential
Input resistance	20 kΩ (differential)
Positive set value	(+ Set Value) > (- Set Value) negative motor voltage or current motor shaft turns CCW
Negative set value	(+ Set Value) < (- Set Value) positive motor voltage or current motor shaft turns CW

5.1.2 Enable

If a voltage is given at “Enable”, the servoamplifier switches the motor voltage to the winding connections. If the “Enable” input is not switched on or is connected to the Gnd, the power stage will be highly resistant and will be disabled.
The “Enable” input is short-circuit protected.

Enable	Minimum input voltage	+ 4.0 VDC
	Maximum input voltage	+ 50 VDC
	Input resistance	15 kΩ
	Switching time	typ 500 µs (by 5 V)
Disable	Minimum input voltage	0 VDC
	Maximum input voltage	+ 2.5 VDC
	Input resistance	15 kΩ
	Switching time	typ 100 µs (by 0 V)

5.1.3 DC Tacho

Minimum input voltage	2.0 V
Maximum input voltage	50 V
Input resistance	14 kΩ

Speed control range:
The speed range is set using Potentiometer **P3 n_{max}** (max. speed at maximum set value).
For full speed control with ± 10 V, the tacho input voltage range must be at least ±2 V.

Example for DC-Tacho with 0.52 V / 1000 rpm:
2.0 V tacho voltage is equivalent to a speed of approx. 3850 rpm. If the full set value range has been used, the lowest adjustable speed with the n_{max} potentiometer is 3850 rpm.
Lower speed ranges can be reached through a reduced set value range or by using a DC tacho with a higher output voltage, such as 5 V / 1000 rpm.

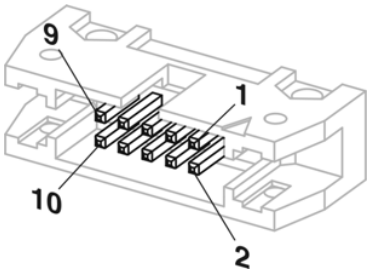
5.1.4 Encoder

Encoder supply voltage	+ 5 VDC max. 80 mA	
Maximum encoder frequency	DIP switch **S5** ON:	10 kHz
	DIP switch **S5** OFF:	100 kHz
Voltage value	TTL	
	low	max. 0.8 V
	high	min. 2.0 V

It is strongly recommended that the encoder be used with a built-in line driver. If the encoder is used without a line driver (without ChA\ and ChB\), speed breakdowns and max. speed limits must be expected because of the slower switching slope.

The servoamplifier does not need any home impulse I and I\.

Male header (front view)



Pin configuration at “Encoder” input:

1	n.c.	Not connected
2	+5 V	+ 5 VDC max. 80 mA
3	Gnd	Ground
4	n.c.	Not connected
5	A\	Inverted Channel A
6	A	Channel A
7	B\	Inverted Channel B
8	B	Channel B
9	n.c.	Not connected
10	n.c.	Not connected

This pin configuration is compatible with the flat cable plugs in Encoder HEDL 55xx (with Linedriver) and the MR encoders with line driver, type ML and L.

5.2 Outputs

5.2.1 Current monitor "Monitor I"

The servoamplifier makes a current actual value available for monitoring purposes. The signal is proportional to the motor current.
The "Monitor I" output is short-circuit protected.

Output voltage range	-10 ... +10 VDC
Output resistance	100 Ω
Gradient	approx. 0.4 V/A
positive voltage on current monitor output	corresponds to a negative motor current
negative voltage on current monitor output	corresponds to a positive motor current

5.2.2 Speed monitor "Monitor n"

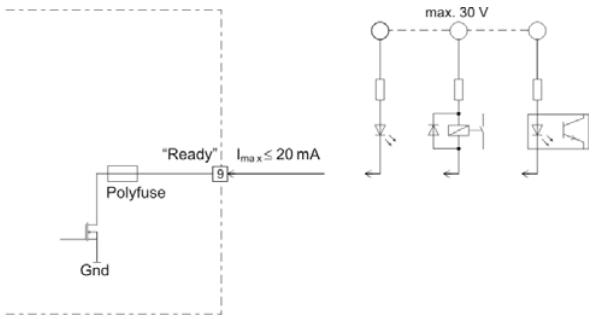
The speed monitor is primarily intended for the qualitative estimation of the dynamics. The absolute speed is determined by the properties of the speed sensors and by the setting of the n_{max} potentiometer. The output voltage of the speed monitor is proportional to the number of revolutions. The output voltage of the speed monitor is 10 V when the maximum number of revolutions set by the n_{max} potentiometer has been reached.
The "Monitor n" output is short-circuit protected.

Output voltage range	-10 ... +10 VDC
Output resistance	100 Ω

Example:	-10 V	corresponding speed	$-n_{max}$	(CCW)
	0 V	corresponding speed	0 rpm	
	+10 V	corresponding speed	$+n_{max}$	(CW)

5.2.3 Status reading "Ready"

The "Ready" signal can be used to report the state of operational readiness or a fault condition on a master control unit. The "Open Collector" output is, in normal cases, i.e., no faults, switched to Gnd. In the case of a fault due to excess temperature, excess current, voltage progressing error or too high encoder input frequency, the output transistor is disabled.



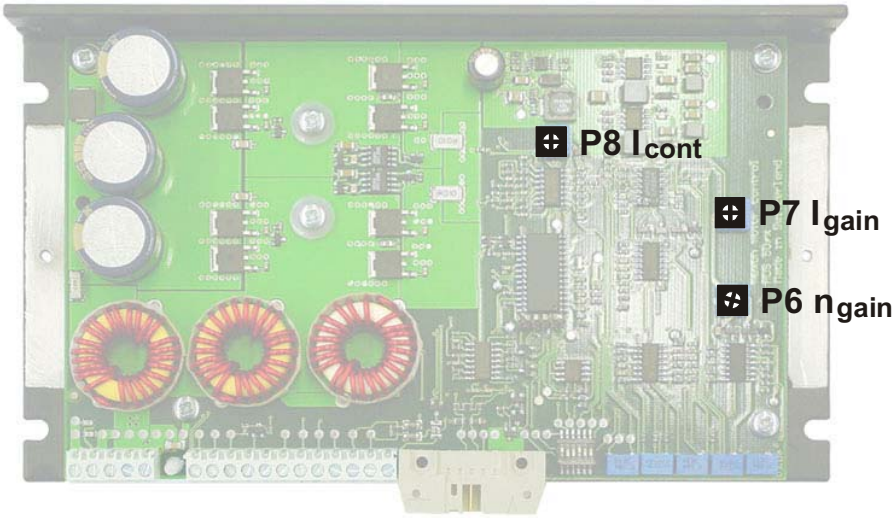
An external additional voltage is required:

Input voltage range	max. 30 VDC
Load current	≤ 20 mA

The fault condition is stored. In order to reset the fault condition, the servoamplifier must be re-released (Enable). If the cause of the fault situation cannot be removed, the output transistor will immediately change to the not conducting state again.

6 Additional Possible Adjustments

	Potentiometer		Function	Position left	Position right
	P6	n_{gain}	speed gain	low	high
	P7	I_{gain}	current gain	low	high
	P8	I_{cont}	continuous current limit	lower	higher



6.1 Adjustments potentiometer P6 n_{gain} and potentiometer P7 I_{gain}

In most applications, regulation setting is completely satisfactory using potentiometers **P1** to **P5**. In special cases the transient response can be optimized by setting the **P6** “speed regulation gain” potentiometer. The **P7** “current regulator gain” potentiometer can, in addition, be adapted to the dynamics of the current regulator.
It is recommend that the success of changes to the settings of **P6** $\mathbf{n_{gain}}$ and **P7** $\mathbf{I_{gain}}$ be checked by measuring the transient response with an oscilloscope at the “Monitor n” and “Monitor I” outputs.

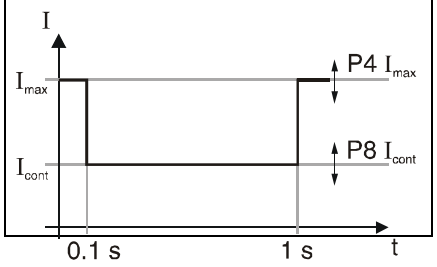
Pre-adjustment **P6** $\mathbf{n_{gain}}$ = 25 % and **P7** $\mathbf{I_{gain}}$ = 40 %.

6.2 Adjustments potentiometer P8 I_{cont} and current limit mode DIP switch S6

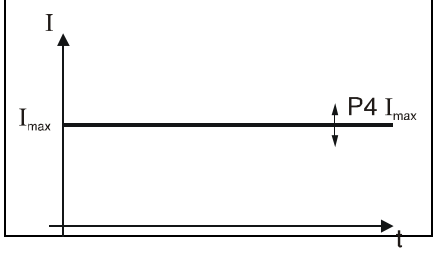
It is standard that a maximum current limiter is activated (DIP switch **S6** OFF). In this way the motor current is limited to the value set on potentiometer **P4 I_{max}** (0.5 ... 20 A).
If DIP switch **S6** is turned to ON, a cyclical current limiter is also activated. This current limiter method makes a certain level of motor protection against thermal overload possible.
For 0.1 seconds the motor current is limited to the value set on potentiometer **P4 I_{max}** (0.5 ... 20 A) and then for 0.9 seconds current is limited to the value set on potentiometer P8 I_{cont} (0.5 ... 20 A). After one second the cycle will repeat itself.

Pre-adjustment **P8 I_{cont}** = 50%.

DIP switch **S6** ON ↑
cyclical current limiter active



DIP switch **S6** OFF ↓
maximum current limit active



6.3 Maximal encoder frequency DIP switch S5

DIP switch **S5** permits selection of the maximum encoder input frequency.
A max. encoder frequency of 100 kHz is standard.

DIP switch **S5** ON ↑	
Max. Input frequency is 10 kHz	
Encoder pulse per turn	maximum motor speed
16	37 500 rpm
32	18 750 rpm
64	9 375 rpm
128	4 688 rpm
256	2 344 rpm
500	1 200 rpm
512	1 721 rpm
1000	600 rpm
1024	586 rpm

DIP switch **S5** OFF ↓	
Max. Input frequency is 100 kHz	
Encoder pulse per turn	maximum motor speed
128	46 875 rpm
256	23 438 rpm
500	12 000 rpm
512	11 719 rpm
1000	6 000 rpm
1024	5 859 rpm

Note
To achieve good control characteristics, encoders with low impulse counts per turn should be run with the DIP switch **S5** ON ↑.

7 Operating Status Display

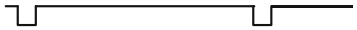
A two coloured red/green LED shows the operating mode.

7.1 No LED

Reason:

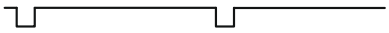
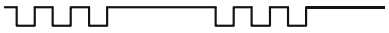
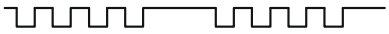
- No supply voltage
- Fuse fault
- Wrong polarity of supply voltage
- Short circuit of the +5 V output

7.2 LED shines green

Blink pattern (green LED)	Operating Conditions
	Amplifier is activated (Enable)
	Disable function active

7.3 LED shines red

According to the blink pattern the following error messages can be identified:

Blink pattern (red LED)	Operating Conditions
① 	If the power stage temperature exceeds a limit of approx. 90°C, the power stage is switches off (disable status).
②	If a motor current of more than approx. +/- 25 A is detected at the current actual value, the power stage will be switched off (disable status).
③ 	If the internal supply voltage cannot be set-up as expected the power amplifier is switched off (disable status).
④ 	If the input frequency at the encoder input is > 150 kHz, the power amplifier is switched off.

The fault condition is stored. In order to reset the fault condition, the servoamplifier must be re-released (Enable). If the cause of the fault condition cannot be eliminated, the error output will be disabled again immediately.

Reason:

- High ambient temperature (blink pattern ①)
- max. continuous current > 10 A (blink pattern ①)
- bad convection (blink pattern ①)
- Short circuit on the motor winding (blink pattern ②)

8 Error Handling

Defect	Possible source of defect	Measures
Shaft does not rotate	Supply voltage <12 VDC	check power plug pin 4
	Enable not activated	check signal plug pin 3
	Set value is 0 V	check signal plug pin 1 and pin 2
	Current limit too low	check adjustment pot. **P4 I_{max}**
	Wrong operational mode	check DIP switch settings
	Bad contacts	check wiring
	Wrong wiring	check wiring
Speed is not controlled	Encoder mode: encoder signals	check plug encoder
	DC-Tacho mode: tacho signals	check plug signal pin 5 and 6 (polarity)
	IxR mode: compensation wrong	check adjustment pot. **P1**

9 EMC-compliant installation

Power supply (+V_{CC} - Power Gnd)

- No shielding normally required.
- Star point-shaped wiring if several amplifiers are supplied by the same power supply.

Motor cable

- Shielded cable highly recommended.
- Connect shielding on both sides:
  ADS 50/10 side: Terminal 3 “Ground Safety Earth” and/or bottom of housing.
  Motor side: Motor housing or with motor housing mechanical design with low resistive connection.
- Use separate cable.

Encoder cable

- Although the ADS 50/10 can also be operated without a line driver, using an encoder with a line driver is recommended as this improves interference resistance.
- No shielding normally required.
- Use separate cable.

Analogue signals (Set value, Tacho, Monitor)

- No shielding normally required.
- Use cable shielding with analogue signals with small signal level and electromagnetically harsh environment.
- Normally connect shielding on both sides. Place shielding on one side if there are 50/60 Hz interference problems.

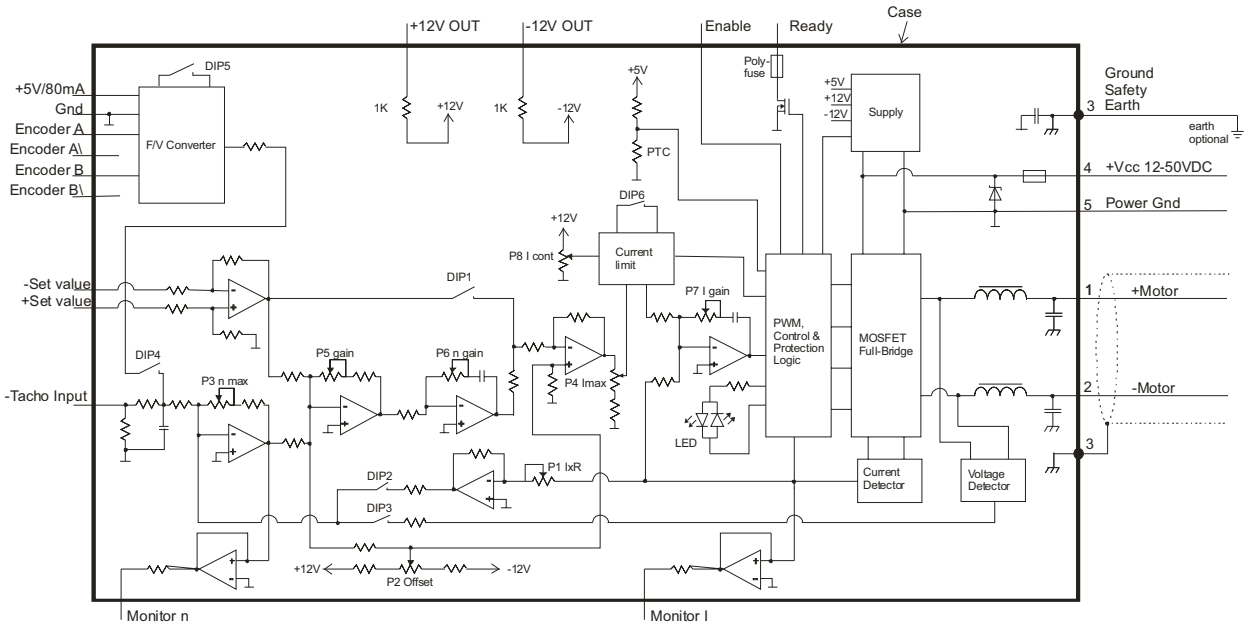
Digital signals (Enable, Ready)

- No shielding necessary

See also block diagram in chapter 10.

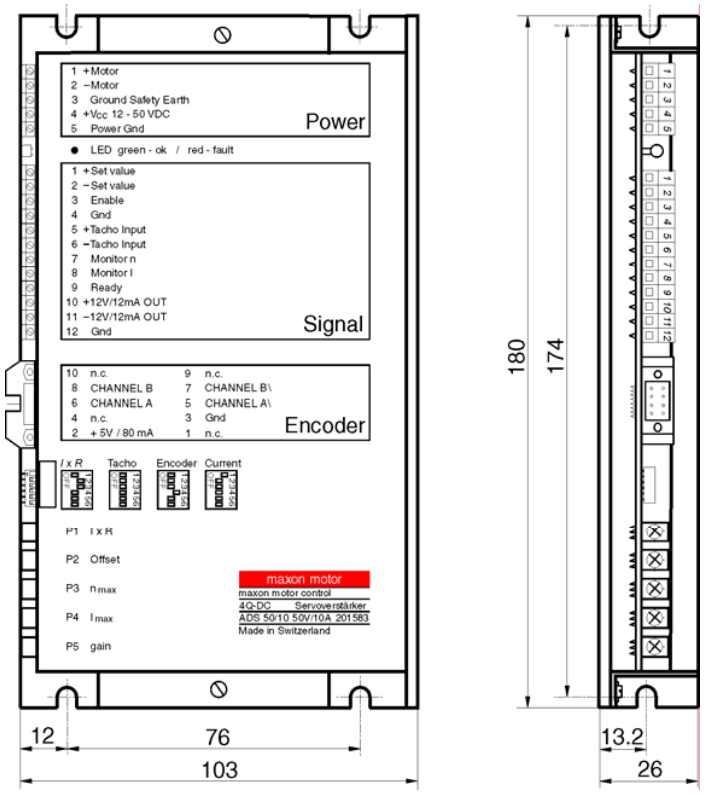
In practical terms, only the complete equipment, comprising all individual components (motor, amplifier, power supply unit, EMC filter, cabling etc.) can undergo an EMC test to ensure interference-free CE-approved operation.

10 Block Diagram



11 Dimension Drawing

Dimensions in [mm]



APPENDIX L

TEST PROTOCOLS

MedTech – MF2003
2008-05-13

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ABBREVIATIONS:

UC	Microcontroller
EL	Electronic
ME	Mechanical
SF	Safety Stops
COM	Communication
GUI	Graphical User Interface

UC01: EVK1101 TEST - LED AND PUSH BUTTONS

GOAL

Each of the numbered push buttons will be mapped to a LED:

- Pressing down push button 0 will make LED 0 light up.
- Pressing down push button 1 will make LED 1 light up.

VERIFICATION METHOD

The goals can be verified with the naked eye.

GOAL VERIFICATION

- ☐ LED 0 lights up when push button 0 is pressed down.
- ☐ LED 1 lights up when push button 2 is pressed down.

……. ……

Date **Signature**

UC02: EVK1101 TEST - PWM SIGNAL

GOAL

A pulse width modulation signal with a frequency of 2 kHz and user controlled duty cycle is to be generated. The duty cycle shall be 0 % when no push button is pushed, 50 % when push button 0 is pressed down and 75% when push button 1 is pressed down.

VERIFICATION METHOD

Verification of the goal requires the usage of an oscilloscope or similar device that presents the actual frequency and duty cycle. Maximum tolerance is 0.4 %.

GOAL VERIFICATION

- ☐ The specified signal is generated when no push button is pressed down.
- ☐ The specified signal is generated when push button 0 is pressed down.
- ☐ The specified signal is generated when push button 1 is pressed down.

……. ……

Date **Signature**

UC03: EVK1101 TEST - COUNTER

GOAL

A signal generator will produce a square wave with rising and falling edges at a set frequency**.** The processor is to count these edges accurately.

VERIFICATION METHOD

As well as a defined counter register, an internal clock is also required. After a set number of edges have been detected, the internal clock register will be read. If the clock register's and counter's respective values correspond to the number of edges generated by the signal generator within that timeframe, the goal is verified.

GOAL VERIFICATION

- ☐ The edges are read correctly

……. ……

Date **Signature**

UC04: EVK1101 TEST - INTERNAL INTERRUPT

GOAL

The microcontroller is to generate an internal timer interrupt every 1 ms.

VERIFICATION METHOD

Verification of the goal requires the use of an oscilloscope. Every time an interrupt is triggered, have the microcontroller toggle an output pin, thereby creating a square wave with a frequency of 1 kHz. Also use debugging to verify that an interrupt does, in fact, trigger.

GOAL VERIFICATION

- ☐ The interrupt is triggered and the expected signal is generated.

……. ……

Date **Signature**

UC05: EVK1101 TEST – VELOCITY CONTROL AND VELOCITY LOGGING

GOAL

The microcontroller controls the velocity of the motor with the PWM by being given a desired velocity in degrees/s. It also logs the velocity from the motor.

VERIFICATION METHOD

Firstly, verify that the motor velocity is the same as the desired velocity by using a tachometer. Secondly, check if the logged ADC value corresponds to the velocity of the motor.

GOAL VERIFICATION

- ☐ The desired velocity is the velocity of the motor.
- ☐ The logged ADC value corresponds to the velocity of the motor

……. ……

Date **Signature**

UC06: EVK1101 TEST – POSITION ADC VALUE

GOAL

The signal received from the position potentiometer is not linear. The goal is to find the actual angle for every ADC value.

VERIFICATION METHOD

Calculate the expression needed to convert degrees into ADC value. Move the driving arm, while it is connected to the position sensor, and continuously print out the ADC value on the HyperTerminal. Measure the angle and verify that the ADC value corresponds to that angle.

GOAL VERIFICATION

☐ The ADC value corresponds to the current angle.

……. ……

Date **Signature**

EL01: AMPLIFIER BOARD TEST – PWM AND ADC SIGNAL LEVELS

GOAL

The purpose of the Amplifier board is to convert one PWM signal to a -10-+10V signal, one -10-+10V signal to a 0-3.3 signal. Noise is also filtered out.

VERIFICATION METHOD

- PWM
    - Generate different PWM signals and analyze signal levels with a oscilloscope
- Analog conversion
    - Run motor in different velocities and analyze converted signal with a oscilloscope

GOAL VERIFICATION

- ☐ The command "full speed ahead" translates to a stable to +10V signal
- ☐ The command "no speed" translates to a stable 0V signal
- ☐ The command "full speed backwards" translates to a stable -10V signal
- ☐ The command "full speed ahead" generates a stable 3.3V signal on ADC pin
- ☐ The command "no speed" generates a stable 0V signal on ADC

……. ……

Date **Signature**

EL02: Sensor Board Test – Signals sent by sensors

Goal

All sensors, position, load and encoders should all be functional and send signals that are usable for each sensors purpose.

Verification method

- Load sensor; press on the load sensor to see that there is a change in voltage. Use an multimeter to measure:
    - Between + and – on connector to get a value.
    - On the amplifier between OUT and REF to get a value.
- Position sensor; measure with a multimeter between signal to the AVR and GND, rotate the sensor to see a fluctuation in voltage.
- Encoder; use an oscilloscope to measure between GND and channel A or B, and analyze the square wave.

Goal verification

- ☐ When pressing the load sensor there is a fluctuation in voltage between + and 1 at a level of 0-10mV
- ☐ When pressing the load sensor there is a fluctuation in amplifier between OUT and REF between 0-3V.
- ☐ When rotating the position sensor there is a fluctuation in voltage between 0-3 V.
- ☐ A stable square wave and the amplitude are above 2.5 V.

……. ……

Date **Signature**

EL03: 12V Voltage Board Test – Voltage conversion

GOAL

The output voltage on this board is a stable ±12 VAC from a 230 VDC input.

VERIFICATION METHOD

- Measure the voltage with a multimeter on the connector for the EVK1101.
- Measure the voltage with a multimeter that the connector for the Sensor Board.

GOAL VERIFICATION

- ☐ EVK1101 connector has a +12 VAC
- ☐ Sensor Board connector has a + and – 12 VAC

……. ……

Date **Signature**

EL04: COMPLETE PCB TEST – TEST OF ALL BOARDS INTERACTING WITH EACH OTHER

GOAL

To get all the boards connected via cords to interact with each other.

VERIFICATION METHOD

- 12V Power Supply Board gets it power from the appliance inlet, measure this on connector (SV2).
- Sensor Board should be powered up via the 12 V Power Supply Board. Measure this with a multimeter on the connector (SV2).
- The EVK1101 should be powered up via the 12V Power Supply Board. This will light a LED (PWRLED) on the EVK that you can see without any tools and just an eye.
- Send a PWM from the EVK1101, i.e. from the AVR32, and measure the photocoupler, PC817 out pin to see that the PWM signal is a stable square wave.
- Plug in the encased powers supply into the Motor Logic Board and measure the connector IN (X4) and validate that there is ~40 V. Then measure that the connector to the H-Bridge (X1) has a voltage of ~37 V.

GOAL VERIFICATION

- ☐ Power Line 12 has a ±12 VAC.
- ☐ Connector (SV2) has a value of +12 VAC between pin 2 and 3
- ☐ EVK1101 lights the PWRLED, located on the EVK1101 board
- ☐ Motor Logic Boards photocoupler, PC817, has a PWM signal.
- ☐ Power Line 48 feeds ~37V to the motor

……. ……

Date **Signature**

EL05: 48V Power Line Test – The encased power supply provides correct voltage.

Goal

The output on this line should be ~37 V.

Verification method

- Measure with a multimeter the voltage output on the encased power supply.
- Measure with a multimeter the output voltage on the H-Bridge connector to the motor (A and B).

Goal verification

☐ The encased power supply feeds ~40 V.
☐ The connector (A and B) on the H-Bridge is ~37 V.

……. ……

Date **Signature**

ME01: MECHANICAL TEST – PARTS IN CONTACT WITH PATIENT MOVE SMOOTHLY

GOAL

The two parts in contact with the patient, the arm holder and hand pad, should be able to be adjusted smoothly with a patient attached to the prototype.

VERIFICATION METHOD

- Fasten a person in the prototype and loosen the screws that hold the arm holder in place. The person should then with no problem be able to lift the arm holder to correct position.
- The user of the prototype should without a person fastened in the machine be able to adjust the height of the arm holder. This is done through loosening both screws and adjusting the height with one hand while tightening one of the screws with the other hand. Then the other screw can be tightened.
- Fasten a person in the prototype and loosen both nuts that hold the arm pad in place. Check that the arm pad moves freely in its rail.

GOAL VERIFICATION

- ☐ The arm holder slides freely vertically with both screws loosened
- ☐ The arm holder stays in position even if only one screw is tightened
- ☐ The hand pad slides freely along its rail with the two nuts loosened

……. ……

Date **Signature**

ME02: RESISTANCE TO CHEMICAL FLUIDS TEST

GOAL

The exterior parts of the SpastiFlex should be cleanable with the sort of cleaning fluids that are used in hospital environments.

VERIFICATION METHOD

The exterior parts are wiped off with a cloth moistened with 70% alcohol. Verify that the surface and paint are not affected.

GOAL VERIFICATION

- ☐ The color of the painted surfaces does not become affected by the cleaning
- ☐ The plastic parts do not change color or is affected in any other way by the cleaning method.

……. ……

Date **Signature**

ME03: FASTENING OF THE PATIENT

GOAL

All types of patients should be rigidly fastened, independent of forearm size. This is important in order to make good measurements.

VERIFICATION METHOD

At least two persons are needed for this test, one with a thin forearm and one with a thicker forearm. These people are fastened using two or three straps on the forearm. Let the person strapped to the machine try to move his arm

GOAL VERIFICATION

- ☐ The fore arm does not move along its axis when subjected to forces from different directions.

……. ……

Date **Signature**

ME04: FALL TEST OF PRODUCT

GOAL

The hospitals are a rough environment for any electronic equipment. It has to withstand falls from normal table height. For example someone might trip on the power cable and drag the product off the table.

VERIFICATION METHOD

The product should be tipped off a table in at least four different directions with different corners first to the floor. It should also be dropped horizontally while being carried.

GOAL VERIFICATION

- ☐ The product is working after each fall. All the mechanics is intact and the unit responds to commands and is able to make an execution with correct measurement data.

……. ……

Date **Signature**

ME05: DISPLACEMENT IN THE DRIVE LINE

GOAL

The goal is to give accurate measurements so almost no displacement in the drive line can be accepted. Any displacement could affect the measurement if the patient, for example, has strong reflexes. The displacement that is critical is between the driving arm and the motor. That consists of displacement between the arm and the shaft, displacement between the gear wheels and the shafts and displacement in the motors gear box.

VERIFICATION METHOD

The measurement of displacement is done through letting the motor hold a fixed position and then moving the driving arm. The displacement is measured in degrees, as the distance the driving arm can be moved without the motor rotating. The motor position can be read using the encoder.

GOAL VERIFICATION

- ☐ The driving arm cannot be rotated more than 1 degree without rotating the motor shaft.

……. ……

Date **Signature**

ME06: Acceptable Sound Level During Tests

Goal

It is important for all medical equipment to give a good impression to the patients. If the motor and gear wheels make too much sound, the product will not give the impression of being safe.

Verification method

- It is sufficient to use one person testing the machine.
- Do five tests with different speeds (5, 50, 120, 200 and 236 degrees/s) when the person is relaxed. Do the same five tests when the person is trying to counteract the products motion.

Goal verification

☐ Normal speech is not drowned out by the sound of the machine while executing a test.
☐ The machine is quiet (except for sound from fans etc) while standing still.

……. ……

Date **Signature**

ME07: Driven Arm Moves Without Friction

Goal

A patient's opposing force is measured between the driving arm and the driven arm. Therefore it's important that the driven arm moves without friction relative the driving arm. This is done using ball bearings on the shafts, but these have to be perfectly aligned to move freely.

Verification method

The motor can be used to hold the driving arm still. The driven arm is unhooked from the load cell and can then be rotated by the person performing the test. Rotate the arm and listen for sounds from the bearings. The rotation should be smooth.

Goal verification

- ☐ There are no sounds from the bearings and the rotation of the driven arm is smooth.

……. ……

Date **Signature**

ME08: RISK OF PINNING PATIENT

GOAL

There's always a risk for pinning a patient since this is a product with moving parts. The operator is assumed to have an understanding for what areas of the product are safe and what areas are not. The patient however might be using the product for the first time without knowing exactly what will happen.

VERIFICATION METHOD

- Use two persons for this test. One with a small hand and one with a large hand.
- Fasten their forearm and hand correctly in the machine and let them try to move their fingers and hand. Check whether they can reach areas where there's a risk for getting pinned. These areas are for example between the driving and driven arm, between the driven arm and the load cell and between the driven arm and the side walls.

GOAL VERIFICATION

☐ A person correctly strapped to the machine could not reach any areas where risk for getting pinned exists.

……. ……

Date **Signature**

SF01: Mechanical Safety Stop Test -

Goal

Ensure that the mechanical safety stops correctly limit the span the motor can rotate the patients wrist.

Verification method

Rotate the cogs directly or by pulling the driving arm.

Goal verification

- ☐ The mechanical safety stops successfully stop the rotation.

……. ……

Date **Signature**

SF02: Electrical Safety Stop Test

Goal

Ensure that the three electrical safety stops are working properly so the SpastiFlex is safe for patients and operators to use.

Verification method

Run the motor with the on/off button on the SpastiFlex and manually press:

- Emergency Stop
- Lower position end switches placed on the side of the device.
- Upper position end switches placed on the side of the device.

Goal verification

- ☐ When pressing the emergency stop the motor stops running.
- ☐ When pressing the lower end switch the motor stops running.
- ☐ When pressing the upper end switch the motor stops running.

……. ……

Date **Signature**

SF03: Software Safety Stop Test

Goal

The goal is to hinder the cog from rotating above or below a set span using software logic. When the driven arm is outside the span the desired velocity is set to zero and the device cannot receive any new commands until it is reset.

Verification method

Since both the GUI and the AVR application do not allow the user to set the angles outside the maximum span the easiest way to verify the goal is to start the device with the driven arm being outside of the span. If outside the span, the device will be set the velocity to zero and be completely unresponsive until reset.

Goal verification

- ☐ The device keeps the driving arm completely still and cannot receive any commands when the driven arm is out of the maximum span.

……. ……

Date **Signature**

COM01: COMMUNICATION TEST – USB CONNECTION TO THE SPASTIFLEX

GOAL

When connecting the USB cord to receive patient data into the PC there is not going to be any problem for the PC to find the device.

VERIFICATION METHOD

Connect the USB cord from the PC to the device. No power up is needed to get this to work.

GOAL VERIFICATION

- ☐ A verification on the PC screen appears and says it has found a new device

……. ……

Date **Signature**

GUI01: GUI TEST – RECEIVING COMMANDS FROM THE USER

GOAL

The program is capable of receiving input from the user and on appropriate events call the USB-driver to send them.

VERIFICATION METHOD

Put a debugging breakpoint on the call to the USB-driver. Run the debugging device, input angles and speed, give a run command.

GOAL VERIFICATION

- ☐ The correct variables are set in the call to the USB-driver.

……. ……

Date **Signature**

GUI02: GUI TEST - RECEIVING AND SAVING DATA

GOAL

The program saves data corresponding to those received.

VERIFICATION METHOD

Write a function that generates data of the same type the one received from the USB-drivers. Put breakpoints after relevant operations made on the data. Start the debugging device. Give the user input that triggers the program to call the data generating function. Check the generated file and import it to some external program for data handling, e.g. Excel.

GOAL VERIFICATION

- ☐ On the breakpoints, the data is of the correct format and, in some random fields in the data array, has the expected values.
- ☐ The data is of the correct format and, in some random fields in the generated file, has the expected values.
- ☐ When plotting the data in an external program it has the expected appearance.

……. ……

Date **Signature**

GUI03: GUI TEST – PLOTTING GRAPHS FOR MULTIPLE RUNS

GOAL

The program is able to plot the data read from files.

VERIFICATION METHOD

Put breakpoints after relevant operations made on the data from files before plotting. Start the debugging device. Trigger it to draw some graphs. Check that the program does the expected operations. Trigger the program to show P1, P2 and P3.

GOAL VERIFICATION

- ☐ On the breakpoints, the data is of the correct format and has the expected values in some random fields in the data array.
- ☐ The graphs and the values of P1, P2 and P3 look as expected and have expected values on some random points.
- ☐ The files read from are unaltered.

……. ……

Date **Signature**

GUI04: GUI TEST – PLOTTING GRAPHS FOR MEAN OF RUNS

GOAL

The program is able calculate the mean values of the data read from files and plot them.

VERIFICATION METHOD

Put breakpoints after relevant operations made on the data from files before plotting. Start the debugging device. Trigger it to draw some mean values and some separate graphs. Check that the program does the expected operations. Trigger the program to show P1, P2 and P3.

GOAL VERIFICATION

- ☐ On the breakpoints, the data is of the correct format and has the expected values in some random fields in the data array.
- ☐ The graphs and the values of P1, P2 and P3 looks as expected and, on some random points, have expected values.
- ☐ The files read from are unaltered.

……. ……

Date **Signature**

GUI05: GUI TEST – USER FRIENDLINESS

GOAL

The program is understandable and behaves as predicted

VERIFICATION METHOD

Start the program. Check if it is behaving as expected for different operations, even those not thought of as the standard way of doing things. Ask some external persons to run the program and ask them if they understand how the program works and what they would expect from the program.

GOAL VERIFICATION

- ☐ The program behaves as expected.
- ☐ The reference persons does not react to any weird behavior
- ☐ The reference persons does not have decided or common suggestions for improvements.

……. ……

Date **Signature**

GUI06: GUI TEST – INSTALLING THE PROGRAM

GOAL

The program is installable on multiple Windows versions and is easy to install.

VERIFICATION METHOD

Start the installation and follow the instructions on some PCs that have not used the program before and that has a Windows environment and internet connection. Start the program and do some operations, including opening a new patient folder and doing a run with the machine, to check that it works.

GOAL VERIFICATION

- ☐ The program is, after installation, executable on a PC never used for the program before.
- ☐ The program is, after installation, executable in Windows XP and Windows Vista.

……. ……

Date **Signature**

APPENDIX M

ELECTRICAL SOLUTION ONE

MedTech – MF2003
2008-05-13

1 POWER LINE 48 – SOLUTION ONE

This power line is only to support the engine. The engine is designed for 48VDC and has a peek current of ~12A, the chosen H-Bridge has a limitation of 40VDC and a maximum current of 30A so a combination of them is what sets the maximum voltage and current allowed on this power line. To solve the transformation from 230VAC to 48VDC an encased powers supply from Traco Power is used. Its characteristics is 48VDC output, its power is 600W and a maximum current of 12.5A (typical current is at no load to full load range is between 80mA to 3.10A). See Appendix E – Section Others. The encased power supply has an output voltage adjustment range of ±10%, this will give 40.3V when it's lowered to its minimum. So a further reduction of voltage is then needed and is made on the PCB for the motor logic, see chapter 2 for more details about the PCB.

$$P = UI \Rightarrow (41V - 37V) \cdot 12.5A = 50W \quad (1)$$

The maximum current peak will last for around 5ms±1ms and the average current when the motor is running at a constant speed is ~3.0A. That gives a need for a high current diode with a capacity of 6A and around 50V and has a drop of 1V. The reduction is made via three serial connected high current diodes that each gives a reduction with ~1V and after that feeds the H-Bridge. It's from the motor logic PCB the DC-motor finally will get its power along with the EVK1101 that contains the MCU that provides the motor with the needed PWM signal.

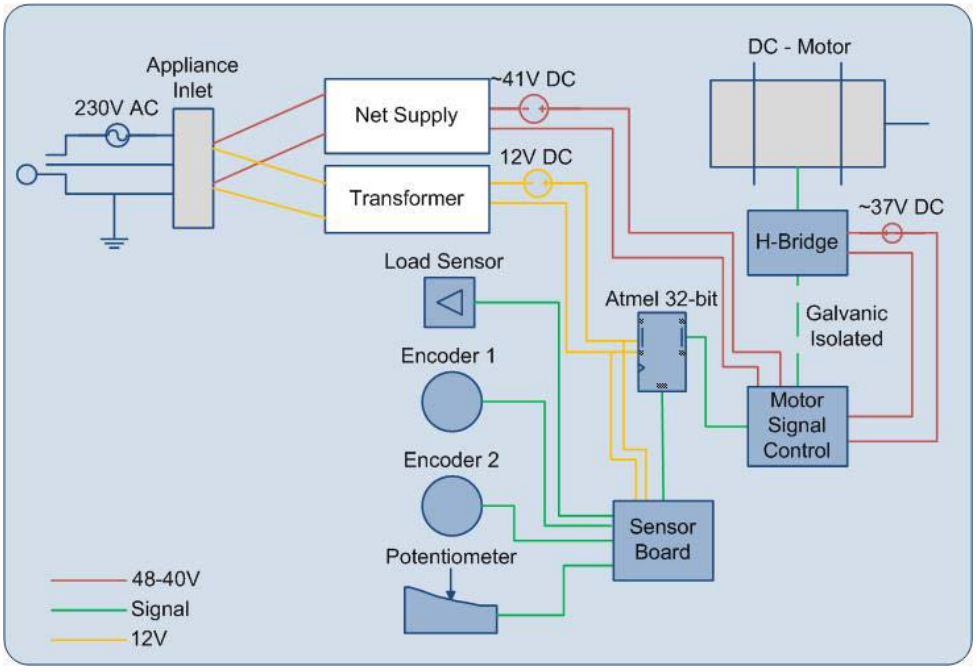


Figure 1 Illustration of Net Supply

2 Motor Logic Board

The motor logic board, Figure 2, has two photocouplers, resistors and capacitors mounted on it. One of the photocouplers is for the PWM signal from the AVR and the other for diagnoses sent back to the AVR. On this board the H-Bridge is placed, Figure 3, and cords drawn from it to the motor and on to it from the PCB. Three high current diodes are used for reducing the voltage from ~40V to ~37V, for the motor and 10 diodes that has a forward drop of approximately 0.7V to reduce the voltage to the voltage regulator which supplies VCC to the logic components. See Appendix D – Section Motor Logic Board for the electronic schematics and PCB layout, Appendix E for Bill of Material and datasheets for used components.

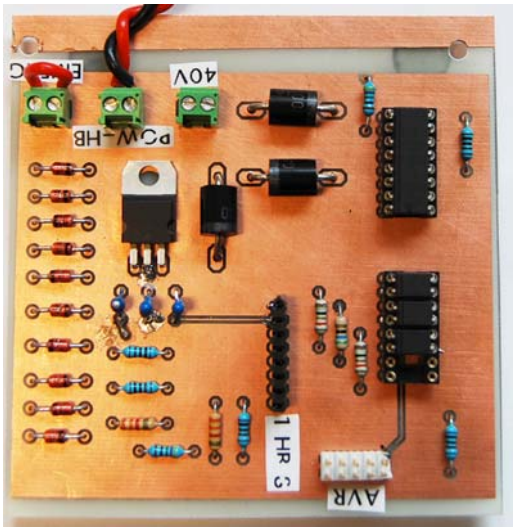


Figure 2 Motor Logic Board

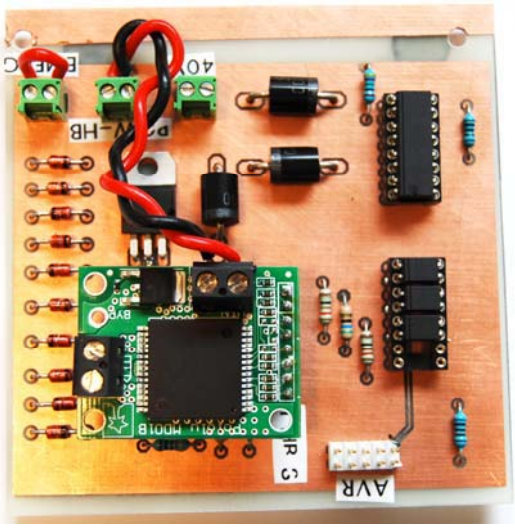


Figure 3 Motor Logic Board with mounted H-Bridge

3 H-Bridge

The H-bridge is an electronic circuit which enables DC electric motors to be run forwards or backwards. To connect the MCU to the motor can be done via an H-Bridge, in this case a readymade board is used, model MCR 02, see Figure 4[1] and Appendix K for its datasheets. On this board an H-Bridge[2] is mounted along

[1] http://www.hobbytronik.se/product_info.php/cPath/30/products_id/105 Available: 2008-03-07

[2] http://www.st.com/stonline/products/literature/ds/12688/vnh3sp30-e.pdf Requires Adobe Reader. Available: 2008-03-07

with connectors and an N-channel MOSFET[3]. The MOSFET is there to protect the H-Bridge from erroneous polarity so that the H-Bridge is not damaged if this happens. The downside is that the total resistance will increase between the motor and the power supply. To avoid this from problem the MOSFET can be disconnected by connecting the bypass pin to ground.

The H-Bridge is used to control the direction of the motors rotation by opening and closing the transistors HSx and LSx in Figure 5. The outgoing voltage, and thereby the motor speed, can be regulated by a PWM signal sent from the MCU. This sets the duty-cycle, the time the transistors are opened and closed. Are they opened half of the time per period, the outgoing voltage to the motor will be half of the supply voltage. Characteristics of the H-Bridge:

Size: 38 x 30 mm
Voltage motor: up to 40 V
Current logic: 5 V
Rds: 34 mΩ
Max current: 30 A
PWM: Up to 10 kHz

Figure 4 H-Bridge

[3] An N-type semiconductor (N for Negative) is obtained by carrying out a process of doping, that is, by adding an impurity of valence-five elements to a valence-four semiconductor in order to increase the number of free (in this case negative) charge carriers. http://en.wikipedia.org/wiki/N-type_semiconductor Available: 2008-03-25

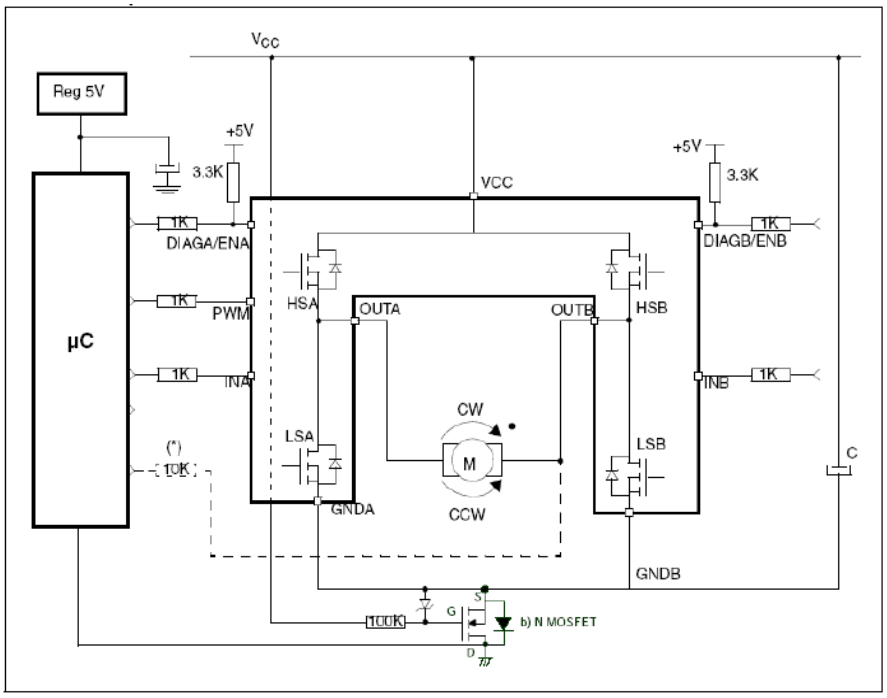


Figure 5 Typical application circuit for DC to 10 kHz PWM operation short circuit

4 CONTROL SYSTEM DESIGN

To be able to fulfill the requirements regarding rise time and the ability to hold a constant velocity despite of outside disturbances, see Appendix C - Kravspecifikation, a PI-controller with low-pass filter is the best choice. The PI-controller is implemented like Figure 6, both as an error feedback part (S/R) and as a feed-forward part (T/R). The process that is controlled is labeled (B/A).

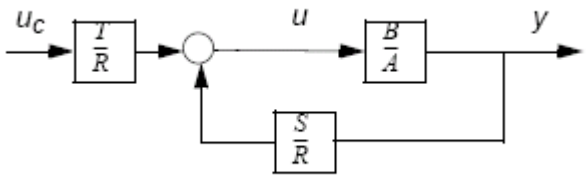


Figure 6 The control design

4.1 CONTROLLER DESIGN

The controller is designed with a method called pole-placement design. It's a design based on the targeted process to be able to create the controller parameters.[4]

[4] Ref till Benkes papper

It starts by choosing a structure of the feedback controller (S/R), in this case a PI with LP-filter for velocity control:

$$\frac{S}{R} = \frac{\mathrm{s1} \cdot \mathrm{s} + \mathrm{s0}}{\mathrm{s} \cdot (\mathrm{s} + \mathrm{r0})} \quad (2)$$

Were *s* is the Laplace-transformation and *s0*, *s1*, *r0* are parameters that depends on the chosen poles and characteristics of the system.
Then the closed loop polynomial, A_{cl}, is calculated like

$$A_{cl} = AR + BS \quad (3)$$

To choose were the poles are to be located, selecting a desired polynomial, A_d, of the same degree as A_{cl}.

$$A_d = A_m A_0 \quad (4)$$

When the error feedback part is designed, the feed-forward part (T/R) is created:

$$T = t0 \cdot A0 \quad (5)$$

Were *t0* is a static gain that gives a dc gain of one and to calculate it use G_{yuc}

$$G_{yuc} = \frac{BT}{AR + BS} = \frac{BT}{A_{cl}} = \frac{Bt_0 A_0}{A_m A_0} = \frac{Bt_0}{A_m} \quad (6)$$

4.2 DISCRETIZATION

The controller is designed for continuous time control, but in the implementation on a microprocessor you will need a discrete controller that works with the defined sample interval. To achieve this, Tustin's approximation (6) is applied on the respective controller parts and thus changing from the continuous time Laplace-transform (s) to the discrete z-transform.

$$s = \frac{2(z-1)}{Ts(z+1)} \tag{7}$$

Here *Ts* is the sample time.

4.3 THE CONTROL LAW

To calculate the voltage needed to obtain and keep the desired velocity use the control law:

$$R(z)\cdot u(z) = T(z)\cdot u_c(z) - S(z)\cdot y(z) \tag{8}$$

And with the discrete controller parts that is approximated by using Tustin's approximation. Then multiply with the shift operator, z^{-2}, which shifts all values that depends on z two samples back in time. In this new shifted control law, all values that is multiplied with z representing the current values (n); z^{-1} represents values saved one sample ago(n-1) and z^{-2} two samples ago(n-2).

$$u(n) = \frac{1}{4 + 2\cdot \mathrm{Ts}\cdot \mathrm{r0}} \begin{pmatrix} 8\cdot u(n-1) - (4 - 2\cdot \mathrm{r0}\cdot \mathrm{Ts})\cdot u(n-2) + \\ (\mathrm{t0}\cdot(2\cdot \mathrm{Ts} + \mathrm{alfa}\cdot \mathrm{Ts}^2))\cdot u_c(n) + (2\cdot \mathrm{t0}\cdot \mathrm{alfa}\cdot \mathrm{Ts}^2)\cdot u_c(n-1) + \\ (\mathrm{t0}\cdot(-2\cdot \mathrm{Ts} + \mathrm{alfa}\cdot \mathrm{Ts}^2))\cdot u_c(n-2) - (2\cdot \mathrm{s1}\cdot \mathrm{Ts} + \mathrm{s0}\cdot \mathrm{Ts}^2)\cdot y(n) - \\ (2\cdot \mathrm{s0}\cdot \mathrm{Ts}^2)\cdot y(n-1) - (-2\cdot \mathrm{s1}\cdot \mathrm{Ts} + \mathrm{s0}\cdot \mathrm{Ts}^2)\cdot y(n-2) \end{pmatrix} \tag{9}$$

From this shifted control law (10) you can get the voltage, u(n), that's going to be fed to the motor during the current sample from old samples and parameters from the system.

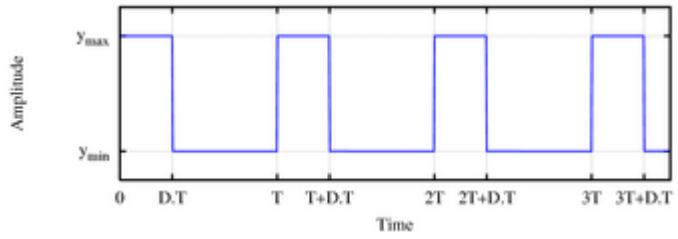
5 Test Protocol - EL01: Motor Logic Board Test – PWM signal on the photocouplers

Goal

The photocoupler, PC817, will have a PWM signal received from the AVR on the output pin that sends the signal to the H-Bridge.

Verification method

- Use an oscilloscope to measure and visualize the signal, set the duty cycle at 50% via the MCU.



Goal verification

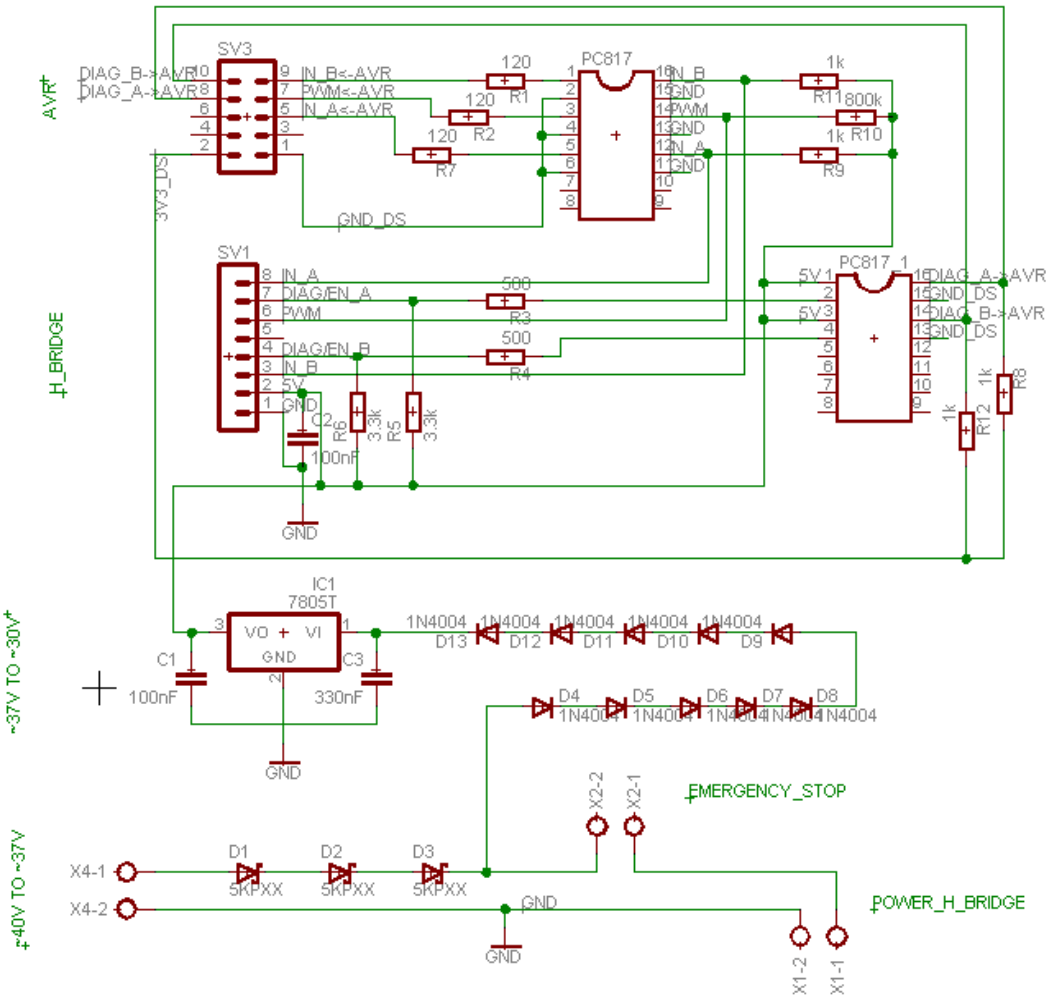
- ☐ PWM signal forwarded to the photocoupler, PC817, is signal in = signal out
- ☐ At a duty cycle of 50% the output should be approximately Y_{max} = 2.5V.

……. ……

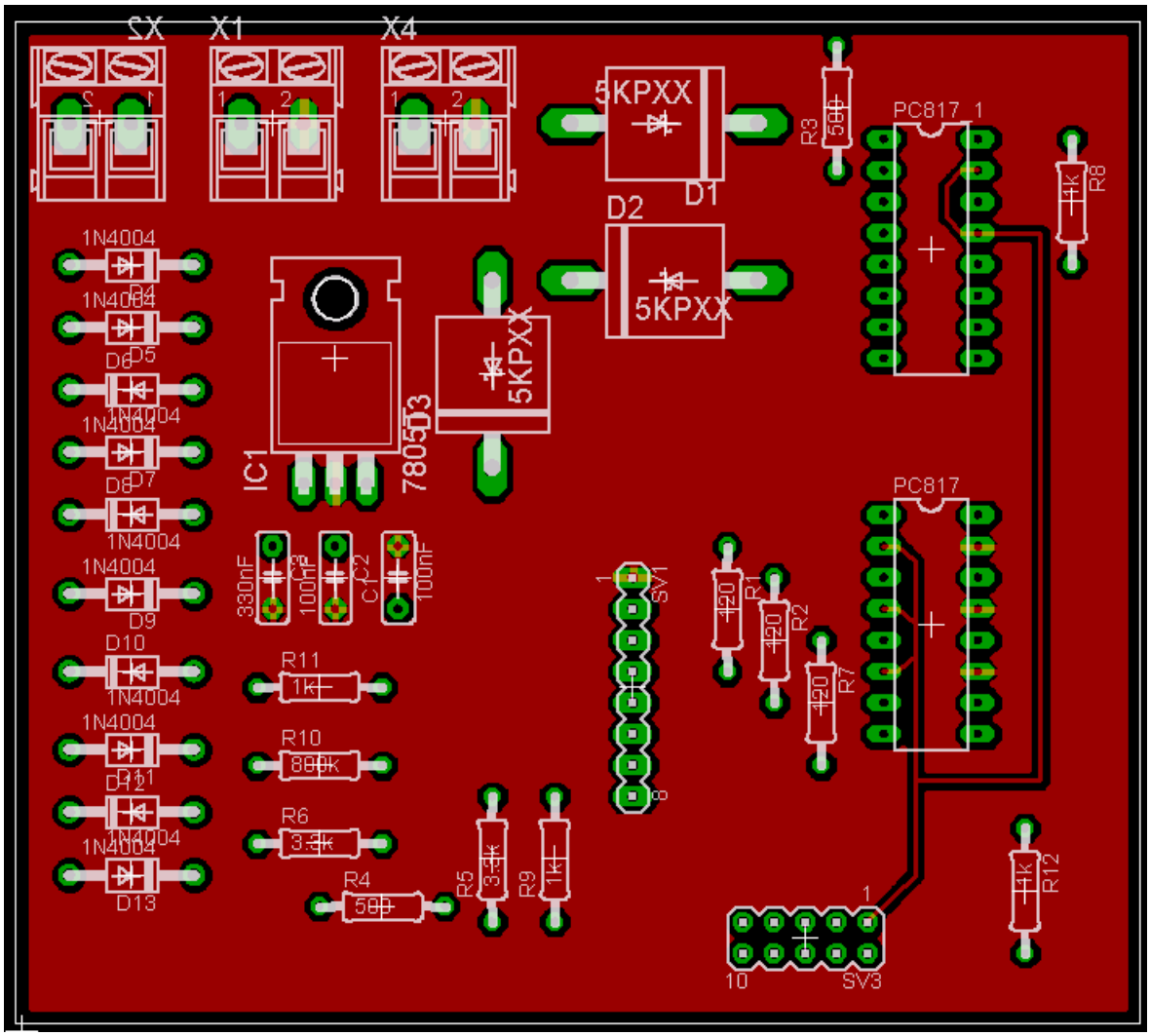
Date Signature

6 SCHEMATICS & PCB LAYOUT

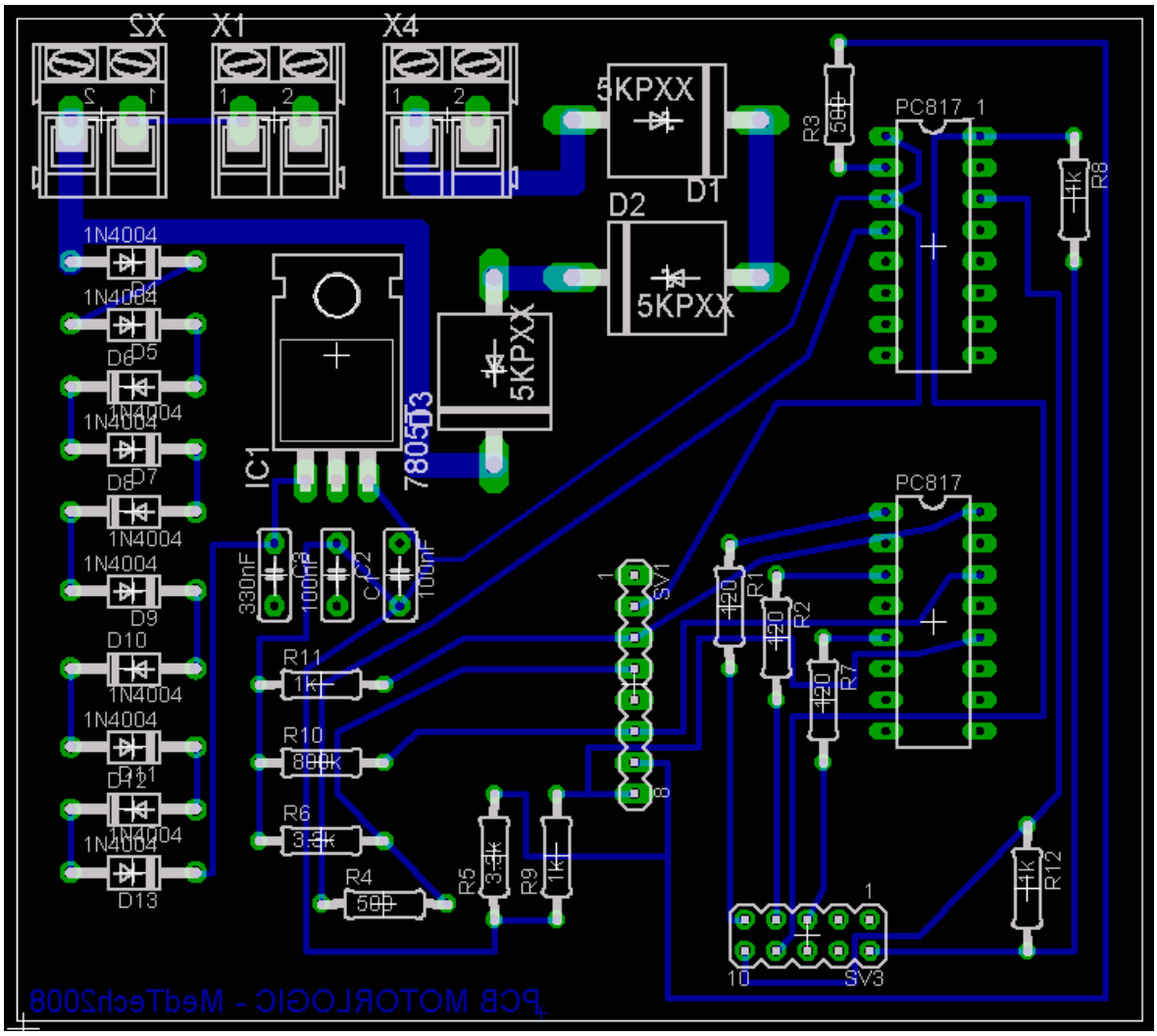
MOTOR CONTROL BOARD



TOP LAYER


X2
X1
X4
5KPXX
D1
D2
5KPXX
R3
PC817
R8
1N4004
D4
D5
D6
D7
D8
D9
D10
D11
D12
D13
IC1
7805
D3
5KPXX
330nF
100nF
C2
100nF
SV1
R1
R2
R7
PC817
R11
1k
R10
R6
R4
R5
R9
1k
R12
SV3

BOTTOM LAYER



7 Bill Of Material - BOM

Motor Logic Board

Part	Value	Device	Package	Library
C1	100nF	C5/2.5	C5B2.5	capacitor-wima
C2	100nF	C5/2.5	C5B2.5	capacitor-wima
C3	330nF	C5/2.5	C5B2.5	capacitor-wima
D1	5KPXX	5KPXX	P6T15	diode
D2	5KPXX	5KPXX	P6T15	diode
D3	5KPXX	5KPXX	P6T15	diode
D4	1N4004	1N4004	DO41-10	diode
D5	1N4004	1N4004	DO41-10	diode
D6	1N4004	1N4004	DO41-10	diode
D7	1N4004	1N4004	DO41-10	diode
D8	1N4004	1N4004	DO41-10	diode
D9	1N4004	1N4004	DO41-10	diode
D10	1N4004	1N4004	DO41-10	diode
D11	1N4004	1N4004	DO41-10	diode
D12	1N4004	1N4004	DO41-10	diode
D13	1N4004	1N4004	DO41-10	diode
IC1	7805T	7805T	TO220H	linear
PC817		DIL16	DIL16	ic-package
PC817_1		DIL16	DIL16	ic-package
R1	120	R-EU_0207/10	0207/10	rcl
R2	120	R-EU_0207/10	0207/10	rcl
R3	500	R-EU_0207/10	0207/10	rcl
R4	500	R-EU_0207/10	0207/10	rcl
R5	3.3k	R-EU_0207/10	0207/10	rcl
R6	3.3k	R-EU_0207/10	0207/10	rcl
R7	120	R-EU_0207/10	0207/10	rcl
R8	1k	R-EU_0207/10	0207/10	rcl
R9	1k	R-EU_0207/10	0207/10	rcl
R10	800k	R-EU_0207/10	0207/10	rcl
R11	1k	R-EU_0207/10	0207/10	rcl
R12	1k	R-EU_0207/10	0207/10	rcl
SV1		MA08-1	MA08-1	con-lstb
SV3		MA05-2	MA05-2	con-lstb
X1		AK300/2	AK300/2	con-ptr500
X2		AK300/2	AK300/2	con-ptr500
X4		AK300/2	AK300/2	con-ptr500

8 MATLAB FILE

```
%************************************************************************
**
%   Program computing control parameters for motion control in project
%   MedTech written by Lars Hansson & Johan Edman
%
%   Project executed during spring 2008
%************************************************************************
**


clc, close all, clear all, format short g

%-------------------------------------------------------------------------
--
%                        System Dynamics
%-------------------------------------------------------------------------
--

%   Misc. Parameters
s       = tf('s');                  % Define Transferfunction
lever   = 0.05;                     % Leverarm [m]
g       = 9.82;                     % Gravitation constant [kgm/s^2]

enable_demo         = 0;            % Use real patient data on system
                                    % used in simulink model

%   Powerlimitations
Vmax    = 38;
Vmin    = -Vmax;
Imax    = 12.5;

%   Motor
Kt      = 60.3e-3;                  % Torque constant [Nm/A]
Ra      = 1.16;                     % Terminal resistant [ohm]
L       = 0.33e-3;                  % Terminal inductance [H]
Jm      = 1.34e-5;                  % Rotor inertia [kgNm^2]
Kemf    = (1/158)*((2*pi)/60);      % 1/ speed constant [V/(rad/s)]
dm      = 3.8e-5;                   % friction in brushes TESTPARAMETER

%   Switchbridge parameters
f       = 10*10^3;  % Switchfrequency
T       = 1/f;      % Period
A       = 38;       % Voltage amplitude

%       Gears
n       = 43;                       % Transmition Ratio
Jg      = 0.0039;                   % Inertia of wheels

%   Patient parameters
m       = 0.3;                      % Mass of hand [kg]
dp      = 2.13;                     % Muscular Viscosity Constant
[Nms/rad]
kp      = 4.5;
```

```
offs    = 0;                          % Strain offset [Nm]
%           Deg     Factor
BpScale = [ 0       3;                % Used to simulate inconsistencies
            0.5     11/4;             % in Muscular Viscosity Constant
            2       7/4;              % (which isn't constante)
            4       5/4;
            6       1;];

%       Aggregations
Jtot    = Jm+Jg/n^2;
c1      = Kt/(Ra*Jtot);
c2      = c1*Kemf+(dm)/Jtot;

%   Reference Values
ref     = 240;                          % Desired Velocity Reference
ref     = ref*n;

pos     = 50;                         % Desired Position Displacement
Reference
pos     = pos*n;

%   Derived System dynamics (polynomials)

A       = s + c2;
B       = c1;

%------------------------------------------------------------------------
--
%                       PI-contoller with LP (continious)
%------------------------------------------------------------------------
--

%   Desired Poles
omega   = 400;                  % 300, 0.9, 300 OK in 240 deg/s
Zeta    = 0.9;
alfa    = 400;

%   Positioning gain (PI-reg)
gain_p  = 4;        % Not implemented but can be used if regulate on
int_p   = 1;        % ref.vel = 0 does not work
acc_error = 0;      % Use when reseting integrator before switching
                    % regulator


%   Control Parameters
r0      = 2*omega*Zeta+alfa-c2;
s0      = omega^2*alfa/c1;
s1      = (omega^2+2*omega*Zeta*alfa-2*c2*omega*Zeta-c2*alfa+c2^2)/c1;

%   Error Feedback
S       = s1*s+s0;
R       = s*(s+r0);

%   DIO-polynomials
Am      = s^2+2*omega*Zeta*s+omega^2;
A0      = s+alfa;
```

```
%   Feed Forward
t0      = omega^2/B;    %Am,B (s=0)
T       = t0*A0;

%   Closed loop transferfunction
%         BT
%       -------
%        AR+BS

Gyuff   = B*T/(A*R+B*S);
%step (Gyuff);

%-------------------------------------------------------------------------
--
%                       PI-contoller with LP (discrete)
%-------------------------------------------------------------------------
--


Ts = 1e-3;              % Sample Time

tics = 1000;

R_disc = c2d(R,Ts,'tustin');
S_disc = c2d(S,Ts,'tustin');
T_disc = c2d(T,Ts,'tustin');

Gyuff_disc = c2d(Gyuff,Ts,'tustin');



%-------------------------------------------------------------------------
--
%                       Simulation
%-------------------------------------------------------------------------
--

load demoPatient1.txt;      % Patient data recieved from Anders Fagergren

response = demoPatient1(:,1);
time = [0:Ts:(length(response)-1)*Ts]';
response = [time,response];



%   Create linear respons from BpScale (using fixed time parameters, not
%   degrees as breakpoints

numOfIntervals  = 4;
BpMatrix = [0];

for i = 1:numOfIntervals
    array = BpScale(i,2):-((BpScale(i,2)-
BpScale(i+1,2)))/100:BpScale(i+1,2);
    BpMatrix = [BpMatrix,array];
end
```

```
time2 = [0:0.03/length(BpMatrix):0.03-0.03/length(BpMatrix)]';
BpMatrix    = BpMatrix';
ViscoVariations = [time2,BpMatrix];


%-------------------------------------------------------------------------
--
%                       Control Law
%-------------------------------------------------------------------------
--


% Original (4+2*r0*Ts)*u = +8*u/z-(4-2*r0*Ts)*u/z^2 +
t0*(2*Ts+alfa*Ts^2)*uc-(2*s1*Ts+s0*Ts^2)*y+(2*t0*alfa*Ts^2*uc-
2*s0*Ts^2*y)/z+(t0*(-2*Ts+alfa*Ts^2)*uc-(-2*s1*Ts+s0*Ts^2)*y)/z^2

%                u(n-1)  u(n-2)         uc(n)                    y(n)
uc(n-1)          y(n-1)          uc(n-2)              y(n-2)
% Printouts
disp(' When you have modified the parameters and have placed your
poles,');
disp(' use these parameters when implementing the regulator in a uC:');

u = 1000*(1/(4+2*r0*Ts))*[8, -(4-2*r0*Ts), t0*(2*Ts+alfa*Ts^2), -
(2*s1*Ts+s0*Ts^2), (2*t0*alfa*Ts^2), -2*s0*Ts^2, t0*(-2*Ts+alfa*Ts^2), -
(-2*s1*Ts+s0*Ts^2)]

disp(' Are the coefficients for: u(n-1), u(n-2), uc(n), y(n), uc(n-1),
y(n-1), uc(n-2), y(n-2) respectively');
disp(' ');
disp(' Y(n) corresponds to the actuall signal measured at this sample,
');
disp(' Y(n-1) corresponds to the signal measured at the previous sample
and so on');
disp(' ');
disp(' Good Luck / MedTech group, Mechatronics HK 2008')
```

9 Test Patient

2.398644 -.142256
4.698958 .1660927
6.802102 .4981609
9.726788 .8539484
12.12569 1.043702
14.75462 1.328332
17.02207 1.968749
18.50084 2.561728
20.53826 2.988673
22.08276 2.917515
24.02160 2.964954
26.71625 3.747686
28.98370 4.672733
31.11971 5.597781
32.03984 6.072164
32.79565 6.380513
33.84723 6.356794
34.57018 6.167041
34.66877 6.333075
33.97867 6.878615
33.02568 7.542752
31.87553 8.372923
30.95540 9.060778
30.19958 9.867230
30.10100 10.43649
29.80524 10.91087
28.68795 11.21922
27.34062 11.36154
24.87600 11.83592
22.31279 12.52378
19.48669 13.16419
16.06908 13.51998
13.30871 13.63858
10.48261 13.82833
8.872385 14.01808
7.492197 14.27899
6.407763 14.68222
5.684807 15.13288
4.666096 15.84446
3.713109 16.50860
2.825845 17.43364
2.135751 18.64332
1.741411 19.82928
1.905719 21.37102
2.661537 22.65186
3.910279 23.79038
5.750530 24.43080
7.590782 24.69171
9.266725 24.90518
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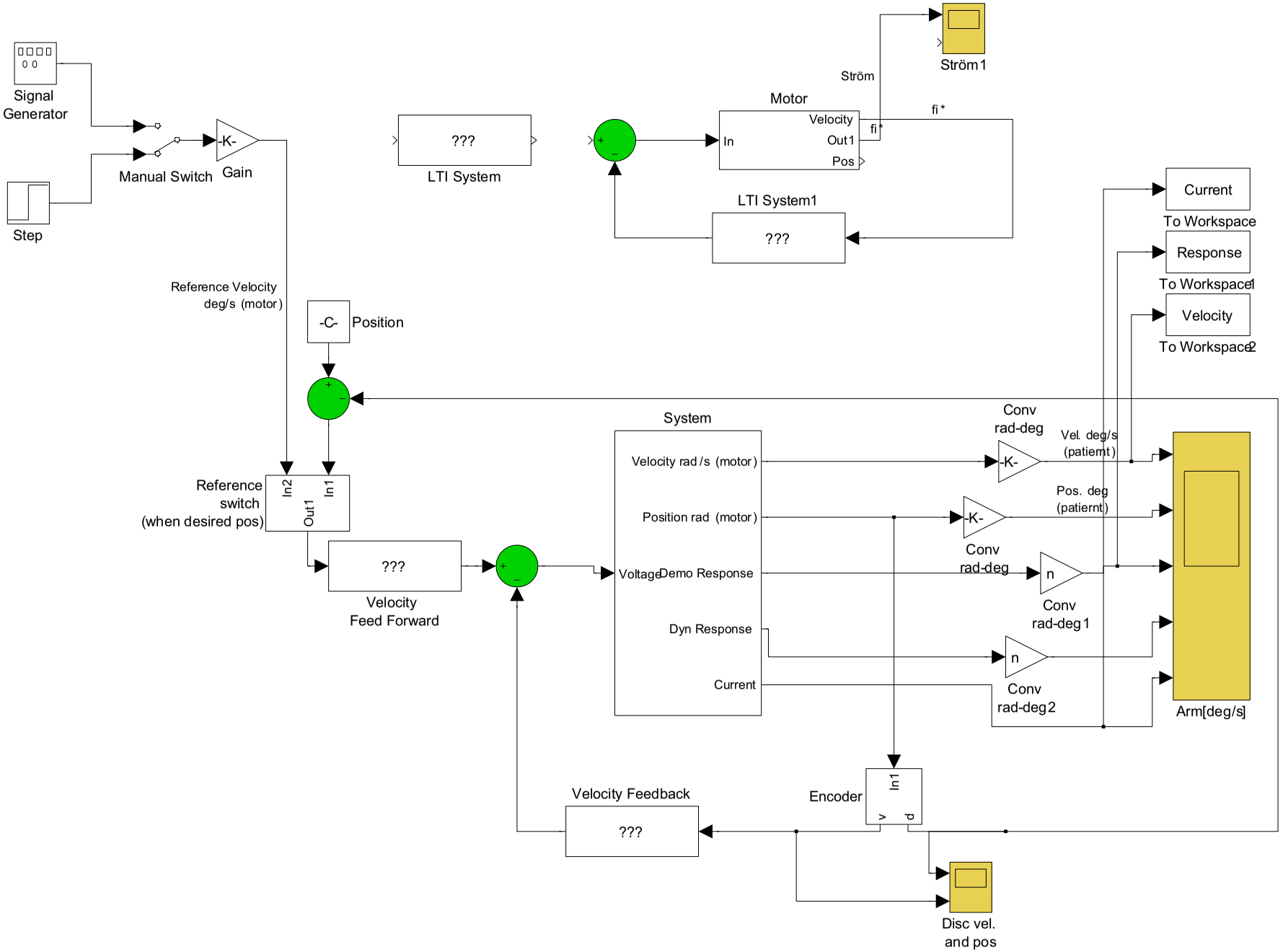
10 SIMULINK MODEL

Simulink Model

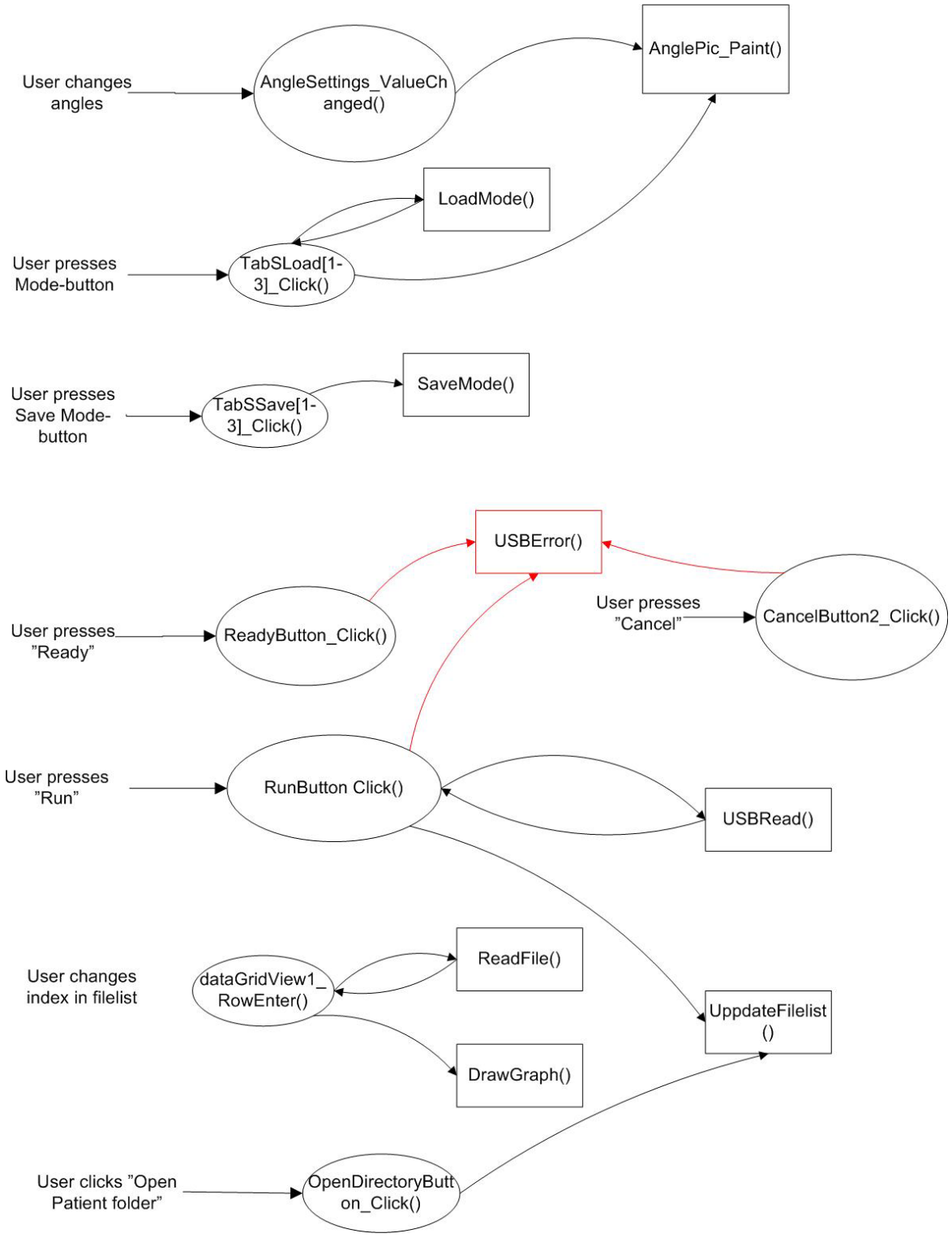


APPENDIX N

GUI DETAILDED OVERVIEW

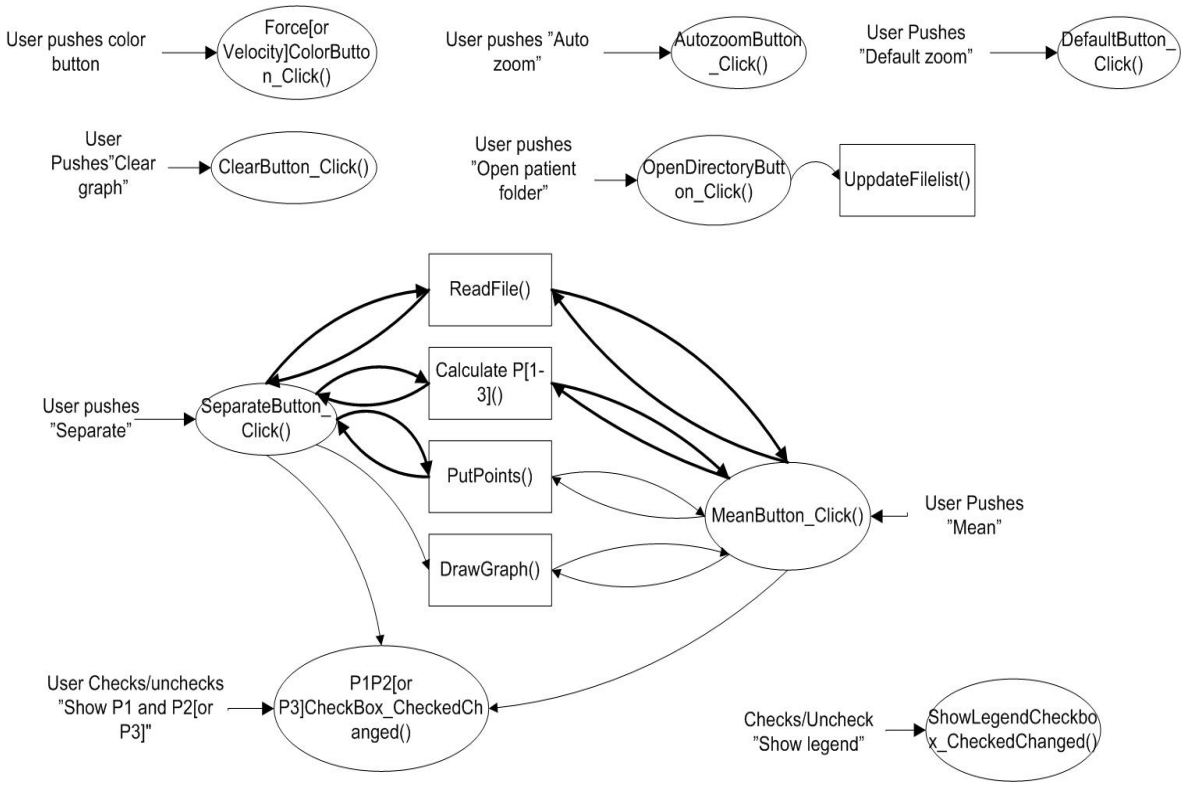
MedTech – MF2003
2008-05-28

1 THE CONTROL FUNCTIONS



2 THE ANALYSIS FUNCTIONS

Thick arrows would represent multiple calls.



APPENDIX O

GUI FUNCTION DESCRIPTION

MedTech – MF2003
2008-05-28

1 FUNCTIONS OF FORM1.CS

`Form1()` `Form1_Load(object sender, EventArgs e)`	Initiates and defines a set of variables, check that the USB is connected, calls `LoadMode(Mode1Filename)`
`AngleSettings_ValueChanged(object sender, EventArgs e)`	Disables `ReadyButton if` angle is to small, and calls `AnglePic.Invalidate()` to trigger the `AnglePic_Paint`-event
`ReadyButton_Click(object sender, EventArgs e)`	Sends USB-report and enables ”Cancel” and ”Run” buttons
`RunButton_Click(object sender, EventArgs e)`	Sends start command to the USB, shows Form2, if run is ok, it obtains the data by calling `USBRead()`, writes the data to a file and calls `UpdateFilelist()` otherwise it displays an error
`CancelButton2_Click(object sender, EventArgs e)`	Sends a stop-command to the USB, enables/disables the appropriate controls and displays an error message

`TabSLoad1_Click(object sender, EventArgs e)`
`TabSLoad2_Click(object sender, EventArgs e)`
`TabSLoad3_Click(object sender, EventArgs e)`
	Calls `LoadMode()` with the appropriate input and calls `AnglePic.Invalidate()` to trigger the `AnglePic_Paint`-event

`TabSSave1_Click(object sender, EventArgs e)`
`TabSSave2_Click(object sender, EventArgs e)`
`TabSSave3_Click(object sender, EventArgs e)`
	Calls `SaveMode()` with the appropriate input

`LoadMode(string ModeFileName)`	Loads a mode-file and puts the loaded values in the appropriate numeric boxes
`SaveMode(string ModeFileName)`	Writes the values of the numeric boxes to a mode-file
`private float[][] USBRead()`	Regenerates a time vector from the set velocity

	of the run, obtains and converts a velocity vector and a torque vector and returns the data
`dataGridView1_RowEnter(object sender, DataGridViewCellEventArgs e)`	Reads the length from the .tst-file selected, calls `ReadFile()` to read the data, and calls `DrawGraph()` to draw the data to `zedGraphControl1`
`ResetButton_Click(object sender, EventArgs e)`	Sends a reset command to the USB
`ReconnectButton_Click(object sender, EventArgs e)`	Tries to reconnect to the USB device
`TabCSave_Click(object sender, EventArgs e)`	Saves and puts parameter values
`TabCReset_Click(object sender, EventArgs e)`	Saves and puts default parameter values
`P1P2CheckBox_CheckedChanged(object sender, EventArgs e)`	Makes the graph objects with the tag `"P1P2"` visible if checked, else invisible
`P3CheckBox_CheckedChanged(object sender, EventArgs e)`	Makes the graph objects with the tag `"P3"` visible if checked, else invisible
`VelocityColorButton_Click(object sender, EventArgs e)`	Shows a dialog box for choosing colors and, if the results are OK, changes the value of `color2` to the selected color and visualizes it
`ForceColorButton_Click(object sender, EventArgs e)`	Shows a dialog box for choosing colors and, if the results are OK, changes the value of `color1` to the selected color and visualizes it
`AutozoomButton_Click(object sender, EventArgs e)`	Sets the properties of the axes in `zedGraphControl2` to autoscale
`DefaultButton_Click(object sender, EventArgs e)`	Sets the properties of the axes in `zedGraphControl2` to certain values
`ClearButton_Click(object sender, EventArgs e)`	Clears all curves and graph objects from `zedGraphControl2`
`SeparateButton_Click(object sender, EventArgs e)`	Calls `ReadFile()` to read all the files selected in `dataGridView2`. Calls `CalculateP1(),CalculateP2()` and `CalculateP3()` to obtain points to use as input to call `PutPoints()` for each of the

	files read. Calls `DrawGraph()` to draw the results. Calls `P1P2CheckBox_CheckedChanged()` and `P3CheckBox_CheckedChanged()`
`MeanButton_Click(object sender, EventArgs e)`	Calls `ReadFile()` to read all the files selected in `dataGridView2`. Calls `CalculateP1(),CalculateP2()` and `CalculateP3()` to obtain points. Calculates the means of the points to use as input to call `PutPoints()`. Calculates the mean of the data and the data. Calls `DrawGraph()` to draw the results. Calls `P1P2CheckBox_CheckedChanged()` and `P3CheckBox_CheckedChanged()`
`AnglePic_Paint(object sender, PaintEventArgs e)`	An event-function that is run whenever windows needs to repaint the `AnglePic` and when `AnglePic.Invalidate()` is called. Draws a pie-chart representing the angles
`Form1_FormClosing(object sender, FormClosingEventArgs e)`	Saves the patient folder name between runs to be selected when the folder browser dialog is shown
`zedGraphControl1_MouseEnter(object sender, EventArgs e)` `zedGraphControl2_MouseEnter(object sender, EventArgs e)`	Makes graph active for zooming upon mouse enter
`dataGridView1_MouseEnter(object sender, EventArgs e)` `dataGridView2_MouseEnter(object sender, EventArgs e)`	Makes list active for panning upon mouse enter
`UsbError()`	Enables/disables the appropriate controls and displays an error message for USB-connection unavailable
`OpenDirectoryButton_Click(object sender, EventArgs e)`	Shows a folder browser dialog and, if the results are OK, saves the path to `PatientDirectory`, copies the mode-files

	to it and calls `UpdateFilelist()`
`UpdateFilelist()`	Updates the file lists with all the .tst-files from the directory path PatientDirectory, shows the last run in `zedGraphControl2`, sets the titles of the graphs to the directory name
`float[][] ReadFile(string FileName)`	Reads a run-file and returns the data
`DrawGraph(float[][][] Data, int[] length, ZedGraphControl surf, DataGridView TheGrid, int LineThickness)`	Generate point pair lists from the data, draws the curves to `surf` with the thickness `LineThickness`, names the legends according to date and time if `LineThickness==1` otherwise names them "mean"

`PointPair CalculateP1(float[][] data)`
`PointPair CalculateP2(float[][] data)`
`PointPair CalculateP3(float[][] data)`
	Calculates and returns point pairs according to `data`

`PutPoints(PointPair p1, PointPair p2, PointPair p3, int thickness)`	Generates text objects according to `p1`, `p2` and `p3` with appropriate tags and with bold if `thickness=2`. Adds the text objects to the graph object list of `zedGraphControl2`
`ShowLegendCheckbox_CheckedChanged(object sender, EventArgs e)`	Shows the legend of `zedGraphControl2` if checked otherwise not
2 FUNCTIONS OF FORM2.CS	
`stopButton_Click(object sender, EventArgs e)`	Sends a stop-command to the USB and closes the form with result `Abort`
`timer1_Tick(object sender, EventArgs e)` `Form2_Activated(object sender, EventArgs e)`	Playing with fancy effects
`CloseWithOK()`	Closes the form with result `OK`